Practical Boat Owner
BRITAIN'S BIGGEST-SELLING BOATING MAGAZINE

20 EXTRA PAGES

ESSENTIAL BOAT MAINTENANCE

SECOND EDITION

New and updated for power and sail

136 pages of PRACTICAL know-how to help you maintain and improve your boat step-by-step

Welcome...

Welcome to the second edition (digital and Print on Demand version) of Essential Boat Maintenance, brought to you by the team at Practical Boat Owner, Britain's biggest-selling boating magazine. In the following pages we've brought together some of the best practical articles ever published in PBO to make a guide that you will keep coming back to year after year.

The first edition (published in 2012 as the Essential Maintenance Guide) proved so popular that we sold every copy. The second edition retained and updated the best articles while adding 10 new features to become our most comprehensive practical publication yet. Now, with this 'Print on Demand' version (renamed Essential Boat Maintenance) we hope to reach more boat owners across the globe.

Whether you're looking to stop your windows from leaking, to service seacocks or apply antifouling, there's something in here for you. There are guides for anyone planning to undertake more ambitious projects such as repairing glassfibre or fitting solar panels. There are also several essential reference articles to help you decide which wood to use for which purpose, find the glues necessary to keep your handiwork as strong as the day you made it, choose the best antifouling paint for the area in which you keep your boat, or check your keelbolts.

Practical Boat Owner magazine is the first port of call for practical articles and advice for many boat owners. If you like what you find, there's plenty more every month in PBO – find it in any good newsagent, subscribe using the details below or visit www.pbo.co.uk and join our mailing list.

Rob Melotti

CONTACT THE TEAM

By email: pbo@ti-media.com
Via our website: www.pbo.co.uk
By post: PBO, TI Media Limited, 2 Pinehurst, Pinehurst Road, Farnborough Business Park, Farnborough, Hants GU14 7B
By phone: +44 (0)1252 555176

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Start the season CHECKLIST

Take the stress out of launch day and ensure nothing is forgotten before your boat goes back in the water with the PBO Essential Maintenance Guide checklist

The green shoots are nosing their way out of the ground, the ice is beginning to melt and launch day – the date you set so nonchalantly back in the autumn – is creeping ever closer while your list of jobs grows ever longer. Despite your best efforts, there's a chance you could forget something vital, so follow this PBO Essential Maintenance Guide checklist to make sure you're able to sleep easy at night.

Ashore

The time to start is while your boat is still laid up ashore. You're probably bringing carloads of kit back to the boat and, while you're at it, it's a good time to check everything's in order.

Anodes

☐ Replace if they are more than 50% eaten away. Even if they look OK, tighten the bolts and use Loctite on the threads.

This shaft anode has reduced by about 50% – time for a new one!

Mast

See page 116 for more about carrying out rig checks

☐ If your mast is down, check the contacts on light bulbs, and that the lenses for your nav lights are not crazed.

Check mast lights while the mast is down at ground level

☐ Clean up the contacts on your VHF aerial and check any wind instruments.

☐ Now is the right time to remove any tape or ties securing running or standing rigging to the mast – you'll thank yourself once it's up and you don't have to shimmy aloft to remove them later on.

If any sheaves are worn, remove the box and replace worn parts

☐ Give the whole spar a once-over, checking for stress fractures and damage to T-terminals, spreader roots and mast heel, and check that your sheaves are not cracked or damaged in any way, and can rotate freely.

☐ Check split pins and rings, replacing if necessary, and make sure that any sharp ends are taped up out of harm's way.

☐ Inspect your roller-furling gear, and grease if necessary.

Winches

☐ Strip, clean and re-grease your winches before reassembling. Replace any broken pawls or springs.

Through-hull fittings

☐ If you removed any hoses, check these are now reattached.

☐ Seacocks have a habit of seizing up over the time you've been out of the water, so work them regularly and grease the ball valve. If you have Blakes seacocks, take them apart and refurbish them (see page 92 to find out how).

Ensure that cockpit drains are free from leaves and debris

☐ Clear cockpit drains of any winter debris. Don't forget the cockpit drain hose seacocks – as these are mostly left open there's a good chance they'll have seized over the winter.

☐ Check the bungs are in your speed and depth transducers.

Engine

☐ Make sure you de-winterise your engine before relaunch.

☐ Replace the water pump impeller.

Remove stuffed rags

☐ Remove any rags stuffed into inlets and exhausts.

☐ Reinstall or replace engine belts you may have removed.

☐ Check the fuel tank for condensation.

☐ Replace all fuel filters.

☐ Consider re-packing your stern gland (see page 132) if it was dripping too much last year and reached the limit of its adjuster. Make sure your stern gland greaser, if you have one, is refilled.

Gas

☐ Check the date on rubber and reinforced hoses: the normal service life of gas hose would be around five years after installation.

☐ Inspect the regulator for any signs of corrosion. (For more on gas, see page 57.)

Check the date on gas hoses

Gas regulators can corrode all too easily

☐ The burners on your cooker may need cleaning as they often rust up.

☐ Check your gas alarm by very briefly placing an unlit gas lighter near one of the sensors.

Heads

☐ Service the toilet (see page 60). Kits are generally available containing all the perishable parts.

Toilet service kits are available

☐ Check the heads seacocks work. If the toilet pump squeaks, squirt in some vegetable oil to lubricate the diaphragm.

Safety kit

☐ If you haven't already done so, it's well worth servicing your lifejackets.

☐ Remove the cylinder and auto-inflation mechanism and orally inflate them, and leave for 24 hours to check for leaks.

Check lifejackets for leaks

☐ Check the lashings on your guardwires for UV and chafe damage.

☐ Check webbing jackstays for UV damage – they could save your life.

☐ Check the expiry dates on your fire extinguishers and your emergency flares.

Electrics

☐ Check the voltage in your batteries, and recharge them if necessary.

☐ You may need to top up lead-acid batteries with de-ionised water.

☐ Smear the battery terminals with Vaseline, which keeps moisture out.

☐ Check deck navigation light bulbs and connections, and that lenses are not crazed.

Rudder

☐ Check your rudder bearings by moving it from full lock to full lock, checking for any grinding or clicking noises. If it's a transom-hung rudder, check for any side-to-side movement.

Anchor and chain

☐ Lay the ground tackle out and inspect for wear and chafe, especially if you have a rope-to-chain splice.

Dinghy

☐ Inflate, check for chafe, wear and any holes. Service your outboard (see page 140).

Bilges

☐ Finally, dry the moisture from your bilges before the boat goes in the water, and vacuum any dust and debris hanging around from the winter's tasks – dust will find its way everywhere unless you remove it now. Having dry bilges before launching means you'll be better able to trace any leaks. Before you descend the ladder in the yard for the last time before she goes in the slings, make sure seacocks, skin fittings and anything else that might leak is easily accessible for when you get afloat.

Final checks once the boat goes back in!

☐ As your boat kisses the water, you should scamper down below and check for water ingress.

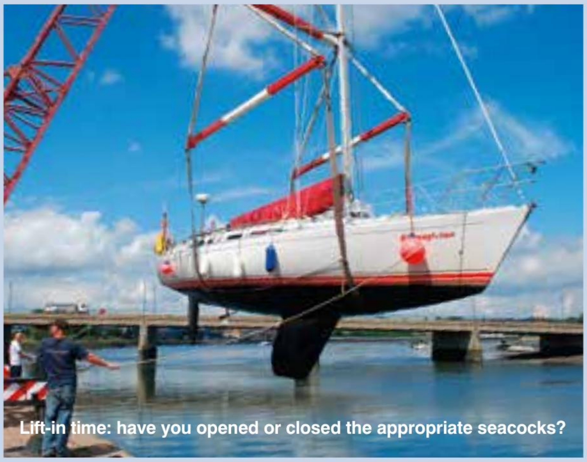
☐ Check all skin fittings and seacocks for leaks, as well as the engine water pump and any drains. If you have a 'Deep Sea Seal'-type stern gland, you'll need to 'burp' it by pulling back the bellows until seawater flows in.

☐ Turn off any automatic bilge pumps until you're sure the boat is dry – they'll hide any leaks until the battery dies and, chances are, you won't then be on board.

☐ A boatyard will plonk your rig back in, but you may need to tension the shrouds and set up the mast rake. If your mast is keel-stepped, make sure the gasket at deck level is secure and watertight.

☐ Check your VHF is working. The coastguard gets swamped at the start of the year, so arrange with your boatyard to give them a call once you're on your mooring, or find a friend's boat to hail.

☐ Give the boat a good run to her mooring under engine and, once the engine is warm, change the oil and oil filters if you didn't do so before the winter.



Lift-in time: have you opened or closed the appropriate seacocks?

Choosing and using wood

Should we steer clear of all wood except teak and mahogany on our boats? Absolutely not, says wood technologist Richard Hare – cheaper alternatives are available, it's just a case of knowing what's best to use where

In PBO's November 2008 issue, John Macfarlane described the restoration of his clinker rowing skiff *Cissie*. He attributed the fine, long-lasting quality of the softwood planking to the original coat of old-fashioned white lead primer. What undoubtedly also played a part were the properties of the species originally selected by the boatbuilder – it was larch.

At the other end of the scale I read about a fellow who went to great lengths and expense to re-deck his yacht in ash, only to find he could pull it up in fistfuls little over a year later. What a waste.

So why did John have a success on his hands when 'ash-man' had a disaster? Well, in this case it boils down to larch having a moderately high resistance to attack by fungi, whereas ash is in the lowest class.

For the same reason we'll never find a timber-frame house built of ash, or elm, whereas there are thousands that are built of oak. Look no further than the bountiful, long-lived, timber-frame houses and pubs across our countryside, particularly in the south.

Yet it remains confusing when it comes to deciding which species to use in various situations on board a boat, and that's before we begin to wonder where we're going to source it. Reassuringly, it isn't the case that expensive and high-durability species like teak have to be used all the time, and this is certainly so when it comes to a dry and properly ventilated GRP boat.

There are two key properties that govern selection:

- **Natural durability** – the resistance to decay by fungi and marine borers.
- **Movement** – the degree a species will expand and contract with changes in moisture content.

Classes of natural durability explained

Fungi class	Description	Durability* (years)	Marine borer class
1	Very durable	More than 25	D – Durable
2	Durable	15-25	
3	Moderately durable	10-15	M – Moderately durable
4	Slightly durable	5-10	
5	Not durable	Less than 5	S – Susceptible

* Based on constant ground contact

Natural durability

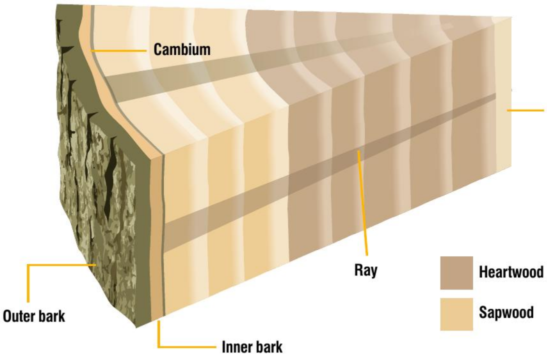
Trees can't go to the toilet in the accepted sense, but they have to 'go' nonetheless – and herein lies the key to their suitability for various applications on board.

A tree feeds itself by lifting minerals in water from the soil and drawing them up its sapwood to its leaves. Here, the minerals are transformed by photosynthesis into digestible food. This yummy tucker is then lowered back down from the crown – this time via the inner bark – and thereon it's transferred into the trunk and branches via the rays.

Sensibly, the tree doesn't gobble up all its food immediately, choosing to take only what's needed. The surplus is stored in its parenchyma cells – the tree's larder if you like – and this tides things over nicely during the winter.

At a tree's centre lies the heartwood – this is actually the

Basic elements of a temperate hardwood



Oak, distinguished by its ribbon-like rays, is great for many uses around a boat, but all sapwood has to be removed to maintain high natural durability

dead part of the tree and is the dumping ground for all the tree's waste products.

The toxicity of this waste – its 'whoopsies' basically, combined with some other extractives – gives a species its natural durability classification (resistance to bio-deterioration). The more toxic the 'whoopsie', the more naturally durable is the heartwood. Yes, it's all a bit indelicate, but it's hard to put it any other way.

This only applies to heartwood. All sapwood – the live wood – even in teak and greenheart, must always be removed from the heartwood unless it is to be kept indoors and in the dry.

There are five natural durability classes, and whereas species classified 1 to 3 are those we use with degrees of confidence for exterior use aboard a boat (not least marine plywood manufactured to BS1088), species in Classes 4 and 5 (ash, maple etc) find niches in interior furniture and joinery in buildings and, with the advent of dry GRP and wood/epoxy boats, to a limited extent below decks on board too.

It wouldn't be advisable to build a hull out of Class 4 and 5 species although, historically, a lot of elm (Class 4) was used for deadwoods and rudders. In these applications it proved OK because, being submerged, it was of too high a moisture content to be at risk of attack by airborne fungi.

The five natural durability classes were developed by testing species left in contact with the ground, which is the worst-case scenario, and it's here that they are most at risk of fungal attack.

CLASS 1 (very durable) and D (marine borers) includes species that will survive in excess of 25 years in ground contact. It includes the boatbuilding jewel, teak, plus opepe, greenheart and lignum vitae, the latter two being more associated with harbour construction. No softwoods make it into this class.

CLASS 2 (durable) delivers 15-20 years and it includes many of the species routinely used in yacht construction both past and present: hardwoods like central American (true) mahogany, utile and oak. Iroko, formerly classed as 'very durable', has since been relegated to this class on account of non-UK laboratories finding it not as favourable as our own. A notable softwood is western red cedar, used on upmarket garden sheds and chalets, and an excellent choice for epoxy/wood strip composite hull construction, not least due to its low density (390kg/m^3).

CLASS 3 (moderately durable), species that will withstand 10-15 years, and M (marine borers). Includes woods that we can use with a degree of confidence. There's no room for complacency though. Bad design – that which traps water – will lead to problems in under two decades, an unreasonably short time in a boat's life. This group includes hardwoods like African mahogany (khaya), sapele and softwoods like larch, Douglas fir (Oregon pine) and pitch pine.

CLASS 4 (slightly durable) timbers rot within 5-10 years, potentially, and the class includes the hardwood elm and many of the builders' merchant joinery softwoods like spruce and Scots pine. They are too low a durability for hull construction, although there are some exceptions. Maple has its uses below decks.

CLASS 5 (not durable) species and S (marine borer) groups should not be used on board in any situation where they may be exposed to the elements, perhaps with the exception of ash tillers and helms.

Class 5 species rot, potentially, within 5 years and include hardwoods like ash, birch and beech. They can be OK for interior veneering and joinery, but always ensure that they are completely encapsulated in varnish or some other impervious surface treatment to keep mould at bay.

Don't even think about using them below the sole.

Hull planks – nowhere else in a boat's construction is the combination of durability and movement more important

Under attack

All wood species, if kept sufficiently dry, will resist fungal attack indefinitely – evidence for which we need look no further than timber brought out of Egyptian tombs after being desiccated in the Sahara for 4,000 years.

Where there are joints there's the potential for fungal decay

Regarding marine borer resistance, teredo will attack ships' timbers below or near the waterline in warmer waters, although this increasingly includes UK waters. So long as we keep up with the antifouling, however, it can be largely overlooked.

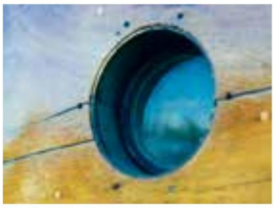
The same applies to gribble, a woodlouse-like fellow who ideally likes to live within the tidal range and can consequently blight boats moored on saltings and mudflats.

Movement

There are three movement classes: high, medium and small. Species with high classification will expand and contract much more, given changes in moisture content, than will species classified as small.

Moisture content (MC) changes are driven not just by contact with water but changes in relative humidity (RH), hence the need for adequate ventilation.

Movement variability between species also explains why two neighbouring carvel hulls that are out of the water for an identical period of time may perform very differently in terms of cracks



Splitting mad – this cabin coaming had dried and shrunk after the metal porthole has been fitted

opening up between the planks.

Similarly, a carvel or clinker hull that's left out of the water too long suffers from cracks in planks midway between the gunwales and the waterline. These planks are at a moisture content below fibre saturation point (FSP, 27% MC). Planks near or below the waterline are well above FSP and won't move (shrink) unless their moisture content is allowed to drop below 27%, hence the importance of not keeping a boat out of the water for too long, especially in dry weather.

Meanwhile, planks near the gunwales tend to be fairly dry anyway, if properly maintained. To be on the safe side and avoid all this worry, in northern Europe it's best not to exceed a normal five-month over-wintering period on the hardstanding.

Wooden hulls made using iroko or teak planks (small movement) can be left up on the hardstanding for over a year with little more than a hairline crack in the paint – if that – while a similar hull planked in larch (medium) will be much more likely to need re-caulking.

So where does this leave us?

Durability and movement together

For many applications on board we must look at natural durability and movement together. From the table (right) we can see that the outstanding hardwoods are teak and opepe, which is reflected in teak's price, particularly. Iroko isn't far behind and it's a great deal cheaper than teak, if not nearly as easily worked.

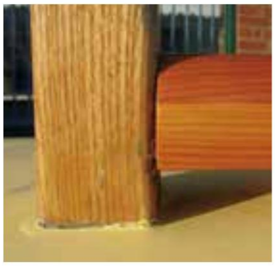
Durability and movement

Hardwood species	Natural durability (class)	Movement
Ash	5	Medium
Cherry	3	No data
Elm (English)	4	Medium
Iroko	2	Small
Mahogany, African (khaya)	3	Small
Mahogany, true	2	Small
Maple	4	Medium
Meranti/lauan	2 to 3	Small
Oak	2	Medium
Opepe	1	Small
Sapele	3	Medium
Teak	1	Small
Utile	2	Medium
Softwood species	**Natural durability**	**Movement**
Douglas fir	3	Small
Kauri	2 (Queensland) to 3 (NZ)	Medium
Larch	3	Medium
Norway spruce	2	Medium
Pitch pine	3	Medium
Scots pine	4	Medium
Sitka spruce	4	Small
Western red cedar	2	Small

Identifying hardwood species

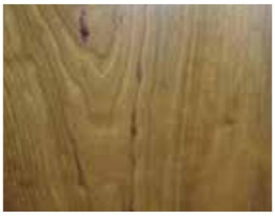
Given that softwoods all look pretty much the same and have limited use aboard, let's concentrate on the hardwoods listed on the durability and movement table

Ash



■ Light creamy colour and indistinct sapwood. Its great features are its toughness and its ability to absorb shocks, hence its routine use in axe and hammer stocks, cricket bats and hockey sticks. Prolonged dampness can easily lead to dark surface mould growth, and this can sometimes occur beneath varnish. Seemingly destined to be an agricultural implement and cart-making raw material for an eternity, its aesthetic qualities have only just become appreciated and we now see it everywhere. Use it for tillers, helms, boathooks and blocks. Rots easily.

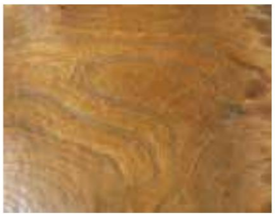
Cherry



■ A pinkish-brown colour with discernible sapwood, cherry has found favour for light and airy interior fitting out. Being Class 3, it can be used in semi-structural applications where there is a risk of moisture problems, although not where at risk from permanent and regular wetting. Cherry is hardwearing and offers an aesthetic quality lighter than mahogany but redder than teak.

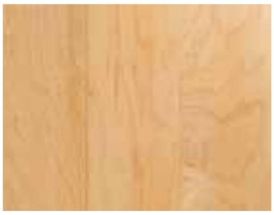
Elm

■ A pinkish-brown colour and a lovely figure, but its role on board is confined predominantly to deadwoods and keels (safe from wet and dry rot). The sapwood is clearly defined. We don't use it any more because Dutch elm disease virtually killed it off in the 1970s, and we're the poorer for its loss. There's plenty of pre-1970s furniture about that has been made with it, and it can be viewed routinely in antique shops. If you have a piece of elm furniture, hang on to it – it'll be a treasured and valuable heirloom one or two generations further on.

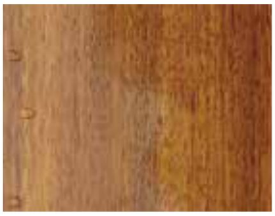


Maple

■ Not a boat construction species on account of its comparatively low natural durability, but its straw/yellow colour makes it good for interior fitting out in dry and well-maintained boats. It's tough and hardwearing, so good for floor panels and, in strip form, it makes a fine hull lining against teak.



Iroko



■ The all-purpose teak substitute, iroko shares much of teak's golden hue, but it tends to darken more with age from a yellowish brown to chocolate brown, particularly when it's kept away from sunlight.

Externally, it tends to remain lighter. Sapwood is clearly defined. It has a slight stripy figure and this is associated with its inclination to be unstable when machined and seasoned. There are very few applications on board that iroko cannot handle, with the exception of spars. Although it's seldom the best in any application, cost-effectively it puts up a very good show in most. It doesn't suffer from nail sickness – a reaction of metal fixings with chemicals within the wood – either.

Modern wood classics like the Finesse range and the Sea Kings are frequently textbook exercises in iroko joinery. Its unfortunate Achilles' heel is the particularly irritating dust it generates when machined. This dust catches in the throat and can trigger considerably more allergies than most.

African mahogany (khaya)

■ African khaya is not related to true mahogany, and comes from an entirely different continent. However, as stocks of true mahogany from Cuba, Honduras and Brazil dwindled, khaya became a popular and plentiful alterative from the 1950s right up until recently, when stocks seem to have become scarce. Let's hope this is temporary and that stands of this very useful species will recover. It has a light pinkish-brown colour, considerably lighter than true mahogany, and it has more pronounced gum deposits in the pores which give it a more speckled appearance. That said, it's a decent-looking wood, and some claim it doesn't suffer from nail sickness like true mahogany.

True mahogany

■ Supplies from Cuba and Honduras have long since dried up, although a trickle of Brazilian mahogany might still be found. It's currently listed as endangered, but sources are hoped to return courtesy of the Forest Stewardship Certification scheme. Its rich red colour, bright lustre and fine figure with tiny flecks of gum deposits made it the darling of every Georgian drawing room in the 18th century. Oak was banished to the backrooms, along with all things Tudor. Once its high resistance to decay was identified, it found favour in luxury yacht construction but, with the growing awareness of nail-sickness, its uses on board became increasingly confined to interior fitting out where its strong aesthetics can be enjoyed. Lit by paraffin lamp, it is resonant of Arthur Ransome and Edwardian yachting yarns like Erskine Childers' *Riddle of the Sands*.

Meranti (lauan)

■ This South-East Asian mahogany substitute is variable in colour and its natural durability can vary between Class 2 and 3, thereby making it suitable for use in marine plywood to BS1088. Dark red meranti resembles mahoganies (khaya too) but lacks an attractive figure and usually looks a bit 'tinny' and plain as a result. It has other uses, for small components, and can frequently be found in plywood form used as bulkheads, although these tend to look a bit characterless if clear-finished.

Oak

■ Oak's appearance hardly needs explaining – we see it everywhere from 600-year-old pubs, to antique dark oak furniture to modern light oak kitchens and dining rooms. What distinguishes it in appearance from horse chestnut is oak's very thick rays which show as yellow/cream ribbons on the radial cut surface. It's very strong, has fabulous figure, and has a high natural durability. Best of all, it grows on our doorsteps.
Its high acidity accelerates the corrosion of iron fixings though, particularly when the wood is moist. This inevitably has an impact on the longevity of iron keel bolts, and these demand periodic inspection and replacement.

Opepe

■ This timber mystifies me. Its Dijon mustard colour tends to exclude it from many applications on board, but its high natural durability (it finds favour as marina decking, above) suggests it is underused as an alternative to elm for deadwoods. Its woodworking properties are fine, which means it might be suitable for beams (we can always paint them) but it hasn't caught on. It probably doesn't come with enough curved grain for frames, though. Either way, I think its high natural durability is wasted down in the deadwoods. The sapwood is distinct.

Sapele

■ This is a sister to utile (right) and with its rich, true mahogany-like red colour and sound natural durability it has been used constantly on board since the mid-20th century. Those of us old enough will remember how it was distinctly *de rigueur* to have striped sapele decks on our racing dinghies in the 1960s. Sapele will deliver a good mahogany effect, but use the lightest tint varnish as sapele darkens more than true mahogany or its sister, utile.

Teak

■ Golden brown that darkens and becomes richer once cut, teak commonly has distinctive dark streaks and a buttery, leathery smell. Even when darkened it retains a light golden lustre, stark contrast to the dark brown and red of mahogany types. Varnishing enhances this distinction and provides a yacht with a lively interior. The sapwood is light and is easy to identify. Since teak is ring porous (a distinct annular ring figure) its figure is similar to oak, ash and elm.

Plantation teak is fine for garden furniture but has dented the species' reputation in the marine sector. Burma, source of the best material by far, is all but exhausted and the country is rife with political problems and trade embargoes. However, old stand teak from southern Sudan is now coming on stream. With its importance to the local economy, Equatoria teak is being managed sustainably under the FSC scheme to ensure long-term availability and maintain a valuable industry for the Sudanese.

Utile

■ Slightly lighter in colour and more open-textured than sapele, utile is more naturally durable and tends to be preferred in the marine sector to sapele. It also shares the characteristic stripy figure of its sister, although to a slightly lesser extent, and is more stable as a result. The colour is a reddish or purplish brown to light brown and might resemble true mahogany more in hue than sapele. The sapwood is distinct.

Wood in action

Some woods are better suited to certain applications on a boat than others. Richard Hare explains which work best in GRP, steel and wooden boats

This GRP-hulled Falmouth Gypsy features plenty of attractive woodwork

Strakes

Teak strakes on this Westerly Fulmar have been allowed to weather grey, thereby saving a lot of work maintaining something that's primarily there to absorb the bumps and knocks of sailing

Moisture can be trapped along the top edges of strakes so they should be made using a moderately durable (Class 3) species or better stuff like khaya, utile, sapele, teak, oak, iroko and meranti. Ensure there's plenty of sealant behind too.

Strakes also need to be amenable to being curved into shape, which puts iroko at a disadvantage. On gradual non-complex curves along a large hull iroko shouldn't be a problem though, and particularly so if it doesn't have too chunky a section. Oak is strong too, and responds well to steam bending. Strakes need to be tough: after all, they're there to absorb bumps and knocks, so softwoods are out. Teak – pliant and durable – is ideal if the budget stretches.

Grabrails and toerails

Although these are well-ventilated applications, moisture trapped beneath makes them vulnerable to fungal attack. Teak is by far the most preferred species. It looks nice as it weathers to a clean silvery colour and is unfazed by a long, damp winter. Although teak is most likely to be used for off-the-shelf grabrails, iroko is a good DIY substitute.

On a modern boat, teak grabrails will often be allowed to weather grey

David Harding

Know which woods to substitute and save £££s

Companionway hatch and boards

If companionway hatches are to run smoothly we should avoid species with even 'medium' movement. Consequently, teak and iroko are excellent candidates.

An iroko companionway hatch, allowed to partially weather grey

Bowsprits

On traditional workboats like smacks and bawleys, softwood was always used. Before the days of glue laminates the shipwright would select a piece of whatever was available but with a wary eye for defects, slope of grain (short grain) and, in particular, knots. With the arrival of pitch pine, fine knot-free lengths became available to make mighty bowsprits.

Nowadays, straight-grained larch makes a good bowsprit, as does sitka spruce, but always select very slow-grown material as otherwise strength will be impaired. Alternatively, iroko makes a fine bowsprit, although it can move. Used chunkily it makes a fine, strong, cat-head sprit.

A straight-grained, knot-free, single-piece softwood bowsprit, either larch or pitch pine, and very slow-grown

Cockpit gratings

Only species Class 2 or better should be used here. A cockpit grating's underside is nearly always damp. Teak is ideal but iroko or oak are good contenders although more likely to warp, given the variation of moisture content from the underside to the upper. They are best left unvarnished and allowed to 'breathe', not least because of the numerous moisture-trapping joints.

This oak cockpit grating has been varnished, but might actually benefit from being left to weather grey

Bulkheads

David Harding

Lighter-toned veneers make the interior of this Bavaria 32 seem quite airy

Bulkheads are primary structural elements and no compromise should be made on natural durability. They are vulnerable to moisture ingress, so marine-grade plywood – with certified resistance to decay – should be used. For surface veneers, many production boats use a dark reddish-brown veneer, though recent trends are towards lighter colours.

Alternatively, if solid wood is to be used for clear-finishing, then tongue-and-groove teak, iroko and oak are strong candidates that can cope with damp bilges and leaking side decks over time, but if the boards are to be painted, larch is fine. Be careful to ensure that all sapwood is removed, though.

For ply bulkheads, use panels made from veneers of Class 3 natural durability or better. Even better is marine ply to BS 1088

Masts and spars

Where weight is important, laminated sitka spruce's low density and comparative lack of knots has made it the favourite for racing boats and modern GRP 'classics'. As for workboats (pilot cutters, smacks etc), solid softwood poles are the norm, and although they come complete with all their knots, this needn't be a problem so long as they aren't in the radial clusters typical of Scots pine. Spruce telegraph poles are strong candidates, not least because they're graded to be able to withstand everything the wind throws at them. Norway spruce poles are likely to be better than pine because the knots (former branches) are located more randomly than in pine and, hence, such poles are less likely to have weakening knot clusters.

Gaff and boom, here in lightweight sitka spruce

Sitka spruce is ideal for mast lamination, masts being a comparatively low hazard situation from a decay point of view.

Douglas fir is also often specified, sometimes in the solid, but it will usually be laminated. The fact that it has higher durability suggests it would be a good choice where a mast goes through the deck and is stepped into the keel.

Decking

Various systems for bonding onto GRP/metal surfaces are available; some teak, others similar-looking composite systems.

Reservations have been expressed about the thickness of some of the bond-down systems so, for those with a will, 6mm teak strips can be bought from a company like Robbins Timber and you can bond down your own wooden surfaces. If attempting this, keep the design simple.

With its high insulation properties, 6mm hardwood decking doesn't just give aesthetic benefits but it also improves comfort below, keeping metal boats in particular a lot cooler in sunny climes.

Teak wins hands down with its high natural durability and small movement. Douglas fir is a cheaper practical alternative, pitch pine too if it can be found, and also iroko, but this can split and crack open.

Nowadays with polyurethane mastic/adhesives like Sikaflex, softwood's 'medium' movement isn't so critical either. There are a number of southern pine species from the US that are related to pitch pine, and grown sustainably. We should confine ourselves to those species that are Class 3, although if we're to get similar qualities to pitch pine then longleaf and slash pine are probably best. Another alternative, if available, is the Australasian softwood, kauri.

Kauri decks on Bosham-built *Lady Maud*

Teak to GRP – this is factory-applied and is Equatoria teak

Whichever species is used, the sealant between the planks must be constantly monitored and maintained, particularly if it's laid on a plywood or GRP sub-deck. Rainwater accumulates out of sight, exploiting the interface between the planks and the sub-deck – the first thing we'll know about it is when the fungus comes crawling out.

To completely avoid the problems associated with deck planks on a wooden boat, it's worth considering plywood sheathed with epoxy mat, subsequently painted. Purists hate the idea of plywood, but it is excellent for stiffening a hull and protecting the structural timberwork beneath.

Boom gallows

This is a well-ventilated situation and so long as there isn't a rainwater-trapping joint between the supports and gallows it's pretty safe from decay. Nonetheless, teak has traditionally assumed this role, and more latterly iroko has been found to be just as good. The important thing is to source a piece of wood with straight grain because any significant slope of grain will lead to weakness, and one that will be exploited when a heavy boom crashes down or is over-graunched once in its groove. For maximum strength it needs to be defect-free and, unequivocally, have no knots.

A thickness of 37mm (1½in) is about right for a boat up to around 9.7m (32ft), and 50mm (2in) minimum for longer boats. It's very important to remember that the effective strength of the gallows is governed by the depth of board after the recesses have been removed.

Teak boom gallows

Soles and sub-soles

Even on GRP boats the bilges can become damp and fetid, so no species Class 4 or 5 should be used. Consider oak and iroko. Larch would probably be fine too.

Class 2 species are best. Opepe might also be used, but teak would be very much a luxury of the rich.

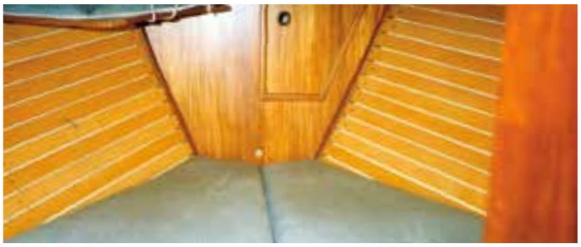
The condition in which we maintain our bilges has a lot to do with the performance of the substructure, and it's no bad thing to scrub down and sluice out the inside of a hull every autumn as part of the laying-up process. Warm soapy water with a healthy splash of white spirit works wonders. Jet all the crud out of the limber holes, lift the locker lids and some of the sole boards and let the cleansing, drying breeze work its magic.

For individual panels, 6mm thick hardwood strips can be laminated into plywood – here it's maple. The bottom of the photo shows Danboline grey-painted WBP plywood

Even with a GRP hull its best to go for something durable under the sole, like the iroko shown

The cabin sole is what we might normally call 'floorboards', and the options for this open up as the upper surfaces of a modern 'dry' boat are well ventilated – well, they should be. Just about anything that's Class 4 or better can be used, including exterior WBP (Weather and Boil Proof) or marine plywood. Furthermore, a thinner plywood might be used with a hardwood strip surface laminated onto its upper surface. Here again it's a dry application (again, it should be…) and maple (Class 4/M movement) can look very pleasing and work well, particularly with teak. Cherry could go well with a dark mahogany interior.

Interior joinery



Wood strips are a good DIY means of dealing with complex hull linings, this forecabin example being maple

In a well-ventilated, dry interior, just about anything discussed here can be used above the sole, even ash which is attractive both in the solid and as veneer. Less risky, from a surface mould viewpoint, maple makes a good hull lining and it looks great with teak. Solid iroko can also look good with teak-faced plywood although it will darken with time.

While teak-faced plywood will give a light golden colour, mahogany types, sapele-faced probably, deliver the dark reddish-brown hue more likely to match older production boats.

Plywood is far more likely to be used than tongue and groove solid wood in GRP and metal boats. Edge lipping is needed to conceal the unsightly plywood end-grain so use teak or iroko on teak-faced plywood and sapele or utile on a mahogany-faced board edge. Brass pin and glue them with standard PVA wood glue, which is water-based and easy to clean up with a damp cloth. Waterproof PVA can also be used for laminating hardwood flooring strips down to their plywood substrate.

For hull lining, 6mm hardwood strips with, say, a 4mm gap, provide a simple means of dealing with complex curvatures. Furthermore, insulation can be bonded onto the hull behind.

As a wooden boat can easily become damp – although theoretically it shouldn't – only those species Class 3 or better should be selected. For cladding, or bulkheads, tongue and grooved hardwoods like iroko work well and look good when they're clear-finished but, if it's to be painted, then larch or pitch pine are fine. Baltic softwood (builders' merchant softwood, Class 4) is best avoided.

Saloon table: khaya plinth, teak-faced ply tops and iroko fiddles

For situations above the sole, marine plywood isn't essential and I've never gone to the expense, preferring a good WBP tropical hardwood plywood. Indeed, gaboon (Class 4) is permitted in marine plywood on account of its light weight.

For battening (making corners) use something Class 3 or better.

Cockpit joinery and exterior joinery

All sub-structure must be Class 1 or 2, so teak, oak and iroko are usually the choice. For lockers, seats and locker panelling, this can be extended to Class 3 species too. For locker lids, teak is well worth going the extra mile for as it doesn't split open so much if left to weather. Utile is a good choice if a reddish hue is sought. It looks great under varnish, but may not weather to such a clean grey as teak and iroko if left unfinished.

Knees are best cut from an oak board with a curved grain. You could well find the exact piece in a sawmill waste bin – it's useless for just about anything else.

Sapele and utile give a traditional 'true' mahogany hue, and they're readily available

Tillers and helms

At last we've found an exterior use for ash aboard a boat – it'll be fine for a tiller, a helm or a boathook. This is because a helm is out in the open and well ventilated. On a leisure boat a tiller shouldn't endure the levels of moisture content that sustain a fungal attack, and especially if it's removed from the rudder stock when not in use and stowed.

Ash is excellent for tillers because of its ability to absorb shocks, but it can suffer from a surface mould growth caused by water ingress beneath varnish, so try to keep the varnish intact.

On workboats like smacks, bawleys and barges the tillers and helms are far more likely to be of oak. These boats, historically at least, inhabit a far tougher world than the leisure boat, hence the need for something a lot more naturally durable.

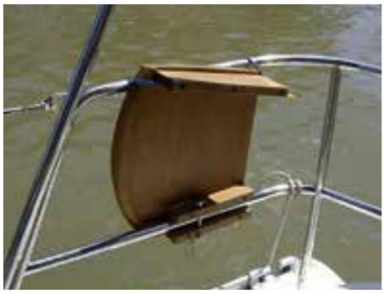
Oak smack tiller – tough and workmanlike, and can be left out in all weather

Fender boards

Softwood is fine here, and scaffold boards are graded to have minimal weakening defects, which makes them ideally suited for the purpose. It's a good idea to attach a second board to the outer surface of your fenderboard to prevent the attachment lines from being ground away on rough quays.

This Beneteau owner found a useful place to stow his fender board…

Cockpit seats and pushpit perches



This fold-away DIY seat was made from wood offcuts bought cheaply at a boat jumble

It's increasingly common to see new yachts with neat little cockpit perches set into the corners of the pushpit as standard. If making them ourselves, there are two options: solid wood, in which case the dimensional stability and durability of teak is a distinct benefit, or we can laminate teak or iroko strips onto a plywood sub-base with a PU mastic/adhesive gunned between the strips. My preference would be to go for a solid plank of teak, if practicable, because it's less likely to be problematic a few years later on. Replacement cockpit locker seats may be constructed by laminating 6mm teak or iroko strips onto plywood. Ensure they're edge-lipped with appropriate hardwood.

The art of veneering

Step by step guide

Face up to the task of applying veneer with the help of boatbuilder Tony Davies

Applying veneer to ply is not exactly an arduous job – it's pretty simple when you know how.

Many people, however, worry about which glues to use. I've been veneering boat interiors for more than 15 years now and all I've ever used is thixotropic contact adhesive.

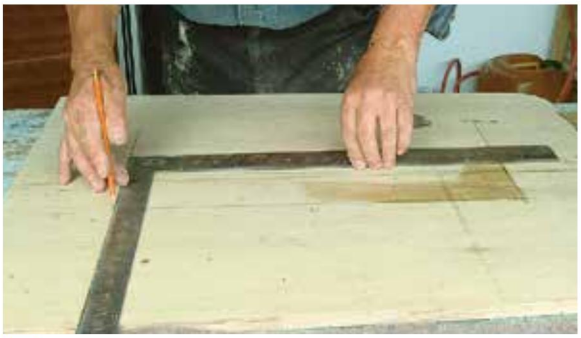
The first veneering job I did was with Thixofix, and this was something of an experiment as I was worried about the longevity of the adhesive. Fifteen years on and it hasn't fallen off yet! Nowadays I use the trade equivalent of Thixofix, Evo-Stik TX528, which is available from builders' merchants in large sizes. I've also used Evo-Stik Timebond when I ran out of TX 528: this works just as well, but is more expensive in retail sizes.

The technique I use relies upon the final finish to protect the veneer and the underlying adhesive, so it is important to properly coat the finished veneer with a high-quality varnish rather than just waxing or oiling the surface. Where a waxed finished appearance is required I use a satin varnish, then wax over that. Whether a gloss or satin finish is required I always use Blakes (now renamed Hempel) Dura-Gloss or Dura-Satin as I find it gives among the best finishes and long-term protection of all the varnishes I have used. You will most likely have your own favourite, though, so use whatever suits you best.

I would emphasise that I only recommend veneering for boat interiors – it wouldn't have much of a lifespan in the open, exposed to the weather.

LEARNING THE BASICS

The first step is to build whatever it is you are planning to veneer: in this case, it is the roof of a heads compartment in the wheelhouse of a 26ft (7.9m) sport fisher. A simple design motif is being incorporated into the veneered panels, which makes this job a little more complicated. It could almost be called marquetry – but it's still not rocket science!



1 **The first stage in this particular project is to mark out the position of the rectangular motif on the ply panel which will become the heads roof.**

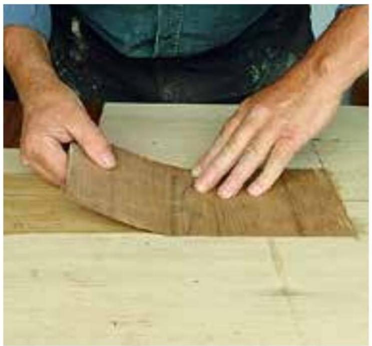
2 **The length of each piece of veneer is then marked.**

3 **The end is squared and marked ready for cutting. The leaf can now be carefully cut using either scissors or a craft knife and straight edge – whichever you feel more comfortable with. Number each one as it is cut to ensure they all end up in the correct positions!**

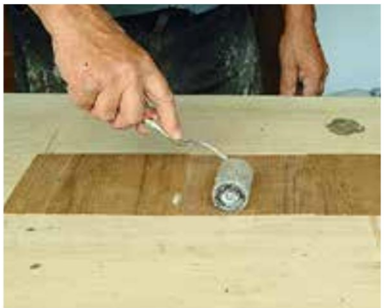
4 **The rest of the set are cut to size and laid in position to ensure they are a neat fit together.**

5 **Adhesive is now applied to the ply within the marked area.**

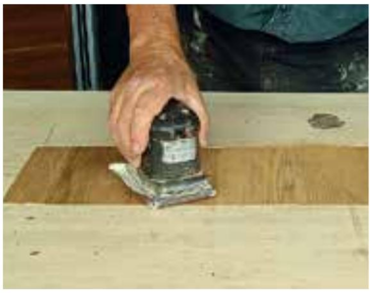
6 **This is followed by an application onto each of the cut veneers. They are left for a few minutes for the adhesive to become touch-dry.**



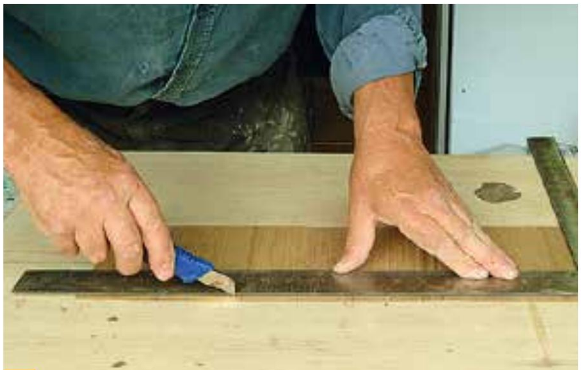
7 The first veneer is then carefully placed into position, followed by each subsequent piece in turn.



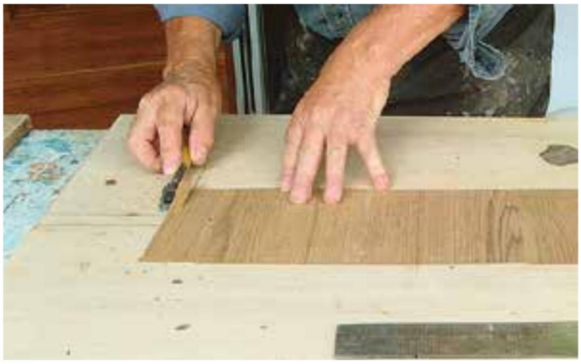
8 Use a roller to apply pressure and ensure the veneer is properly bedded down onto the adhesive. I'm using a glassfibre roller here, but on larger areas I use a vinyl flooring roller which covers a larger area more quickly.



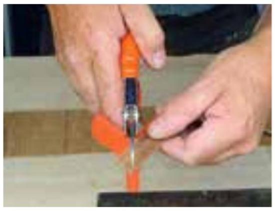
9 Next, a palm sander smooths the veneer surface: at the same time the vibrations help force it more firmly into the adhesive. Sanding dust will fill any tiny gaps between the veneer pieces and be held by the glue. Excess dust can then be brushed from the surface.



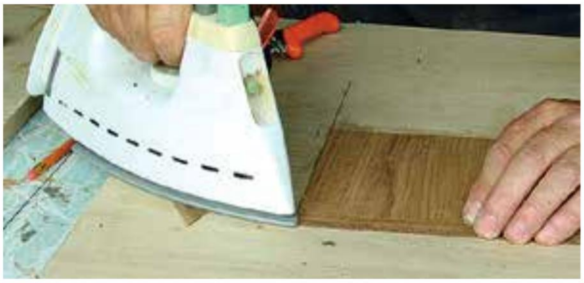
10 Now the veneer is given a final trim using a straight edge and craft knife.



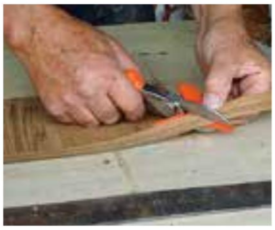
11 After trimming, the excess veneer can lifted with a sharp chisel – the adhesive will not be finally cured for 24 hours.



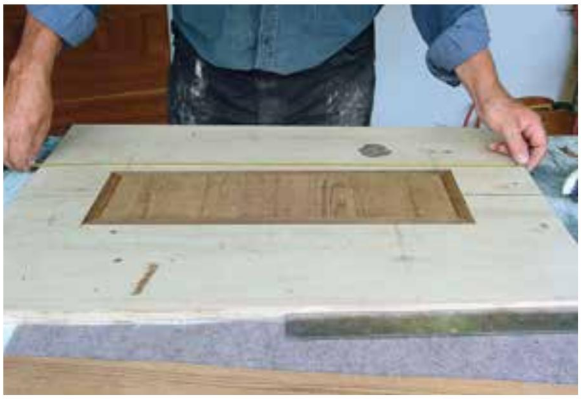
12 For the next stage I'm using teak iron-on edging, bought in 50m rolls from eBay. The first step is to cut a 45° angle for the first corner. I have some vinyl trimming snips with built-in guides, but a protractor and craft knife are just as accurate.



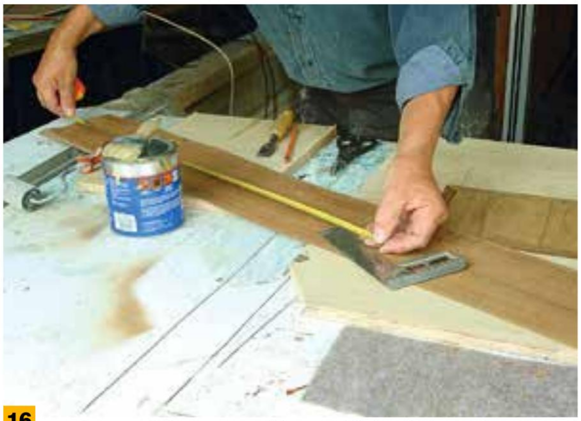
13 The corner is carefully positioned and the iron (set on medium heat) is applied to the end of the edging and pressed down to melt the edging's heat-set adhesive and hold it in place.



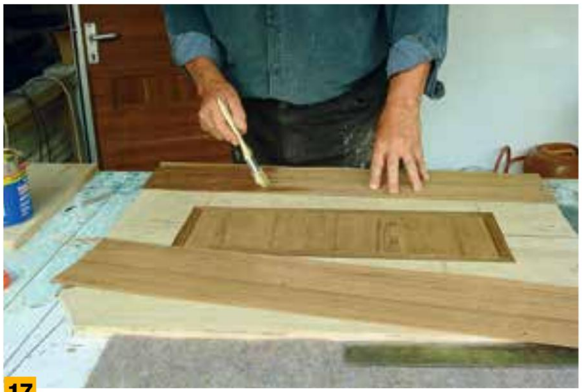
14 Before gluing down the entire length you need to cut the other end of the strip after carefully marking its length. The remaining section can then be heated with the iron and fixed.



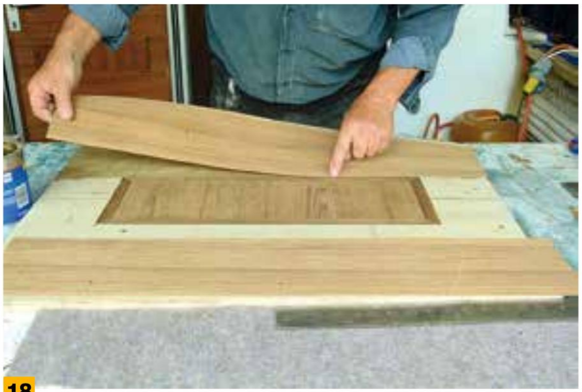
15 The central panel is now finished and I'm ready for the next stage. First I double-check the length of the panel...



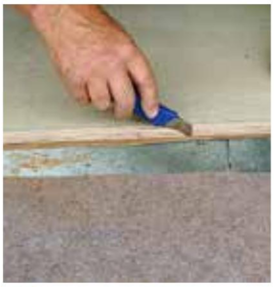
16 ... so I can mark the veneer and then cut it to length.



17 Adhesive is applied to the back of the veneer and to the face of the ply.

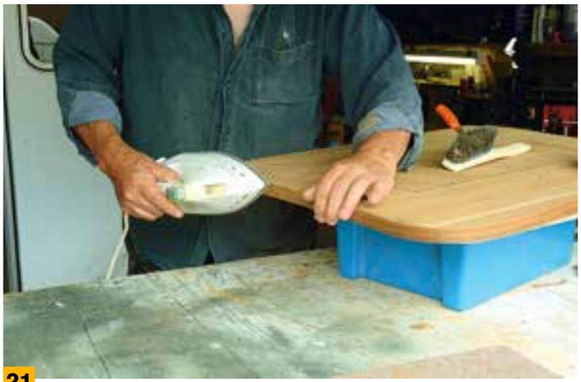


18 Each piece is placed into position and rolled down.

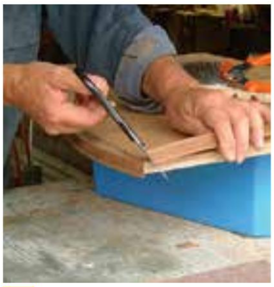


19 Carefully trim excess veneer using the craft knife with a new blade to ensure it does not pull the veneer. Once all pieces are glued down, the entire surface is sanded to smooth and embed the veneer.

20 The edges of the panel are now carefully sanded, taking care to keep square with the front face.

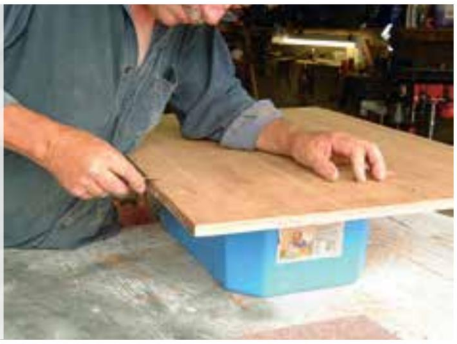


21 An iron-on edging strip can now be applied all around the perimeter.



22 As each corner is reached, the position is marked and the edging cut off square.

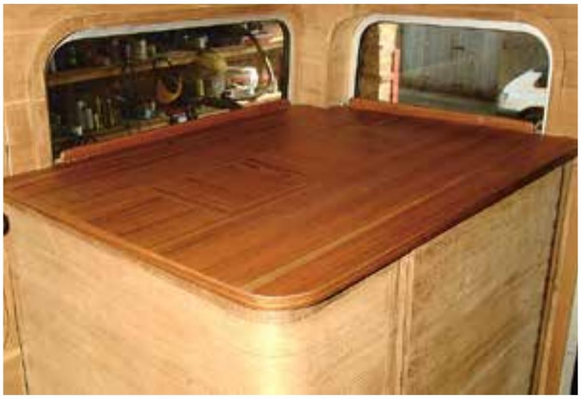
23 Overlap from the edging is now trimmed from both the underside and the top of the panel. Take extreme care when trimming the excess from the face side.



24 The whole panel can now be given a final sanding. Be careful not to over-sand the edges of the panel – it is very easy to sand right through the veneer.

25 Finish off sanding the piece by hand, especially along the delicate edges.

26 A first coat of varnish can now be applied to keep the finished surface clean. This is a satin varnish, which will lose its gloss as it cures.

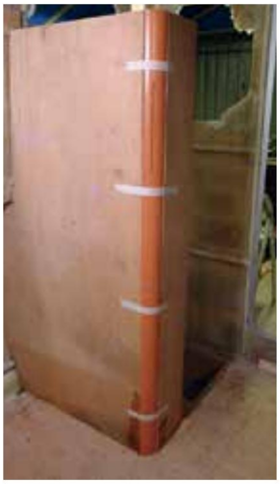


27 With the varnish cured, the completed panel can be placed in position to see how it looks – and it looks pretty good!

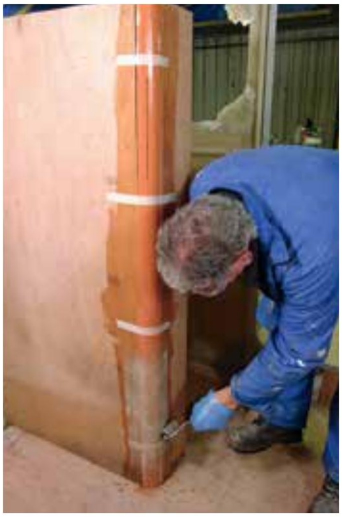
Veneered design features

CURVED EDGES TO BUILT-IN FURNITURE

There is no doubt that rounded corners in boat interiors look very professional and, of course, fewer sharp corners means there's less likelihood of injury when falling against something in rough weather. To obtain the look you either have to perform some very fancy carpentry with solid wood or, if you are using veneer, you can easily achieve the same effect with a slice of plastic drainpipe.



1 Once the basic structure is complete a piece of 100mm (4in) plastic drainpipe is cut down lengthways into quarters, and a single section is placed into position in the recess in the corner of the structure and temporarily held with masking tape.



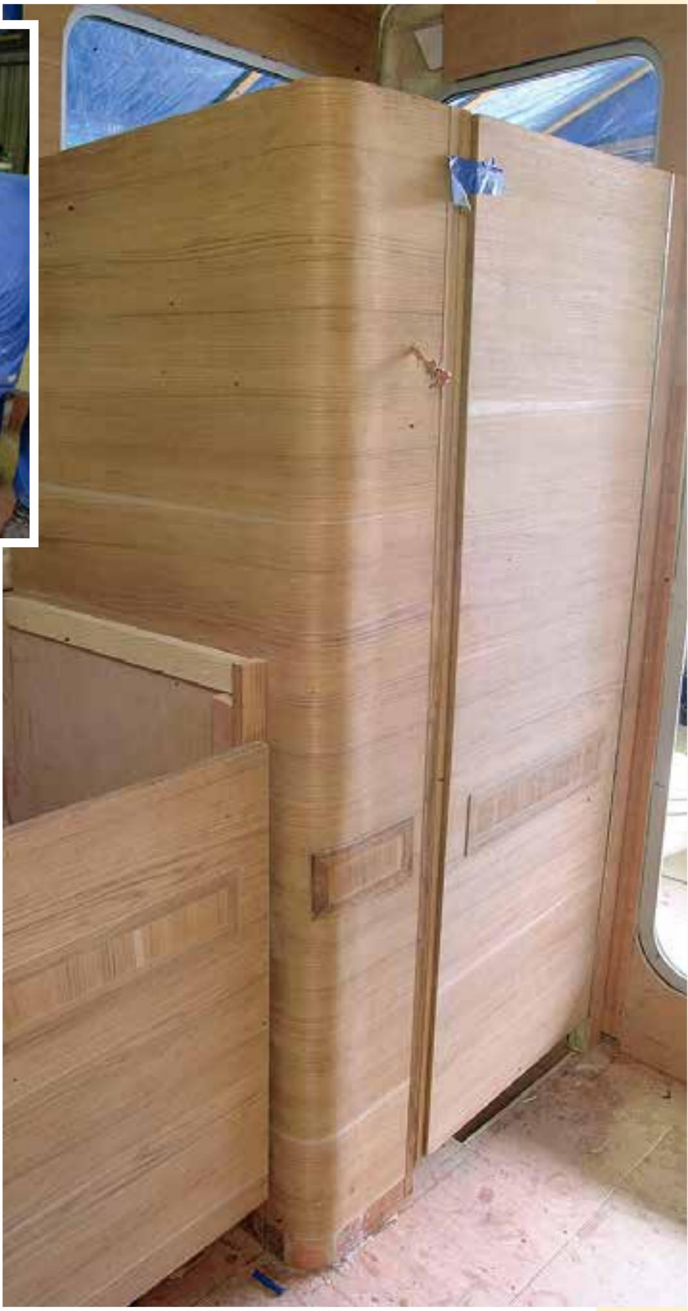
2 A layer of lightweight mat and resin is applied over the pipe section to secure it in place. This is rolled out to exclude air in the normal manner, then left to cure before starting to apply the veneer.

3 As with our previous panel, adhesive is applied to the ply structure: I find a brush easier to use than a spreader.

4 Adhesive is applied to the veneer leaf and, again, both are left for a few minutes to become touch-dry.

5 When ready, the veneered leaf is offered up to the ply, taking care to align it perfectly with the previous leaf before pressing into place. Carefully take it around the curve and align it before pressing firmly.

6 The roller is used to ensure the leaf is perfectly flat and properly stuck.

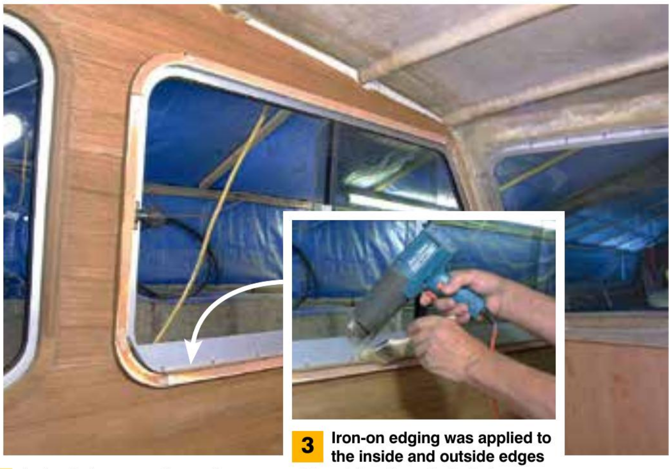


7 Here the heads compartment, its door and an adjacent locker door are ready for varnishing. All carrying the rectangular motif – but in this case they are applied to the face of the veneer rather than being cut in flush.

FRAMES AROUND WINDOWS

In this job I was faced with a superstructure of varying thicknesses (the cabin sides are of different construction to the forward sections) which meant it was impossible to keep all the aluminium window frames looking the same on the inside. So I decided they should all be boxed in using veneered ply to provide a smart, uniform finish.

1 The side windows look neat enough, but to help them match the forward windscreen panels a veneered frame will be required.

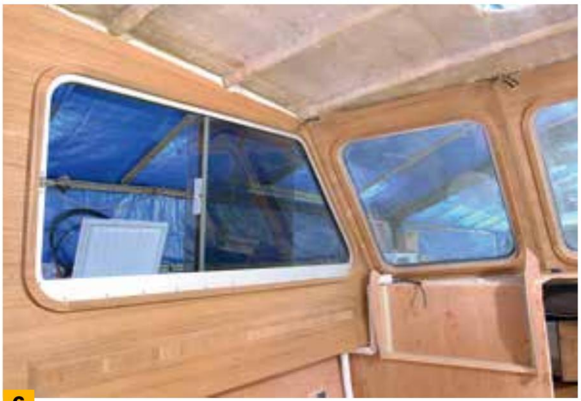


2 A simple frame made up of narrow ply strips was bonded around the window interior frames using polyurethane adhesive.

3 Iron-on edging was applied to the inside and outside edges of the strips. I used a hot air gun to melt the glue, while an ordinary bristle (not plastic) paintbrush smooths the edging into position.

4 I used the handle of the brush to press the edging down to ensure good adhesion.

5 Shaped pieces of veneer were cut to form the corner faces while iron-on edging was used for the straight runs. Once in place they were all then trimmed and sanded in the normal manner.



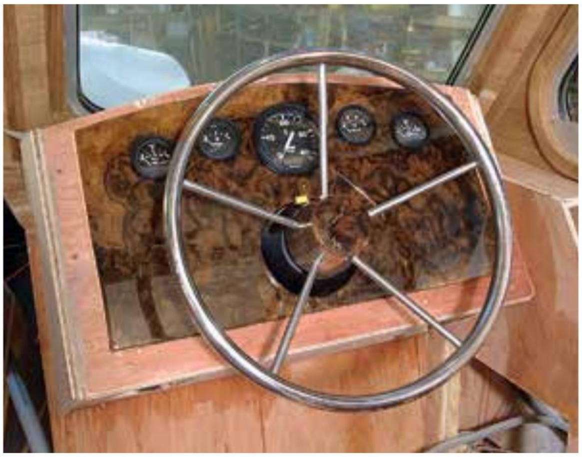
6 The finished frames provide a simple but smart, uniform appearance.

A QUALITY LOOK FOR AN INSTRUMENT PANEL

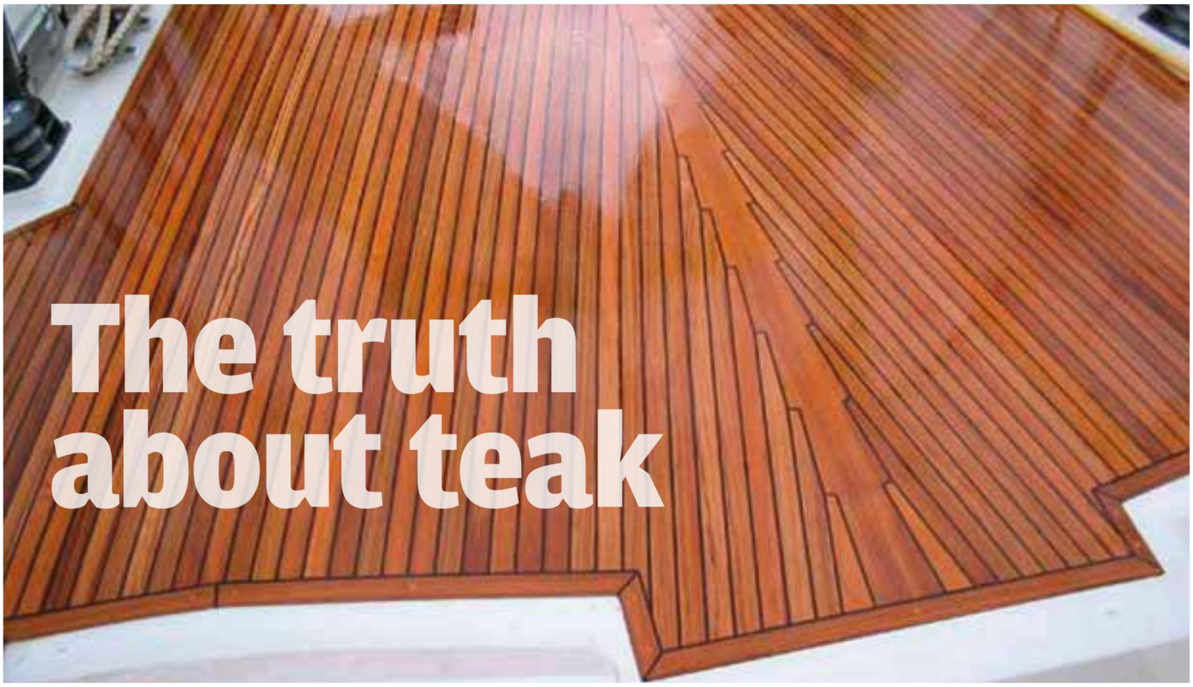
The ultimate car dashboard is still traditional burr walnut, and this is often applied to boats – so I thought 'why not?'

1 Four specimen leaves of burr walnut were bought from a specialist supplier on eBay.

2 The instrument panel was prepared from a piece of 12mm ply. I carefully cut the holes in the veneer after it has been glued to the panel.



3 After many coats of varnish the finished panel looks impressive. The rest of the surround will later be covered with black vinyl.



The truth about teak

Shipwright Robin Benjamin says modern, thin teak decks need a great deal of regular care – so it's vital to follow his advice on how to keep them looking good

In the last 15 years I have worked on more teak decks than I care to remember: I think I've seen every problem that exists. What you have to know straight away is that, like anything, teak decks need looking after. If you take care of your decks they may last 20 years or more, if you don't, you'll be appalled at how awful they look after only five. Because solid teak decks have been the norm for hundreds of years, they have understandably earned a serious reputation for longevity. Today's teak decks are not the same thing at all.

In many cases, modern teak decks are little more than a quick way for the manufacturer to up the 'class' of their product. Many are poorly fitted, the wood is too thin and the caulking gap too narrow. Because of the minimal amount of wood involved the best plug on the deck might only be 3mm deep. Likewise, the caulking, unless of adequate depth and width, will not remain glued as the wood moves. However, all these problems would amount to little if folk took care of their teak decks. The most important advice is to wash the deck every week, but few people can spare the time. It's quite simple however: if you don't wash your deck regularly, it will soon go grey and dirty.

Don't scrub

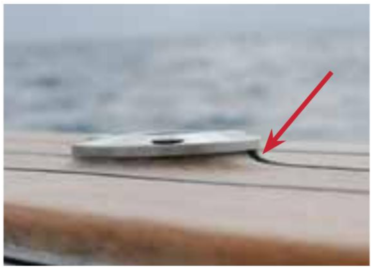
I've seen it done: the owner is standing there, his trouser legs rolled up, his knees red. True, his deck looks great… from the pontoon. But if you look carefully you'll see grooves in the planks where the softer areas of grain have simply vanished. This is how it starts. Consider that you began with a lovely smooth surface, like a CD, for example. After scrubbing it looks more like an LP record, but worse, much worse. Imagine now how quickly the 'peaks' will wear down as you walk on them. Of course it doesn't end here – this is only the beginning.

To keep your deck clean there is only one way, and that is a gentle wash with nothing more violent than a light detergent and a large sponge or very soft brush. If you do this regularly you will not wear down the teak, but you will wash off the dirt before it gets ingrained. Dirt contributes to the wear of a teak deck. If this approach doesn't work then you can try oxalic acid. Dissolve some crystals in warm water, do not breathe the vapours and make sure you wear gloves.

When it comes to timber decking, the thicker the better

Elegant teak decks have adorned high-class yachts for hundreds of years – and the planks are very thick

Even more modest pine decks have stood the test of time because they are made of quite thick planking



This is how worn teak decks can become after only five years of regular scrubbing and sanding

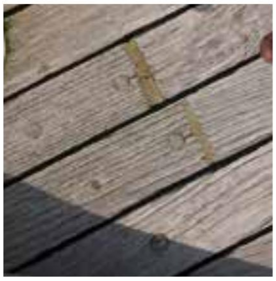
Oxalic acid burns, so rinse well: it shouldn't harm anything on the boat except your skin. There are plenty of products that do the same thing but cost a lot more. If acid doesn't bring back the colour then there's only one thing left to do if you want a lovely-looking teak deck, and that is to sand it. But if you want my advice, continue to wash it carefully and often, with soap, and live with the deck not looking its best.

For some reason, no one listens to me. I gladly advise people on how to look after their decks for free, even if it means I don't get any work. It's better for everyone, except me, that you take my advice – yet despite this I still see people scrubbing their teak. I shake my head in wonder. Did I not explain what would happen if they scrubbed? 'But it looks so great!' they say. 'So what's the problem?' The problem is that the next time they see their decks they will look grey and dirty again. The only difference will be that there is less teak than there was before. If your feet don't wear down the peaks then they'll fill up with dirt, making it look even worse. There's only one way to get it out – more scrubbing. This time you'll have to scrub harder to see a result. Can you see what's happening? There will come a point soon when you decide the decks are looking pretty rough and need a good sanding.

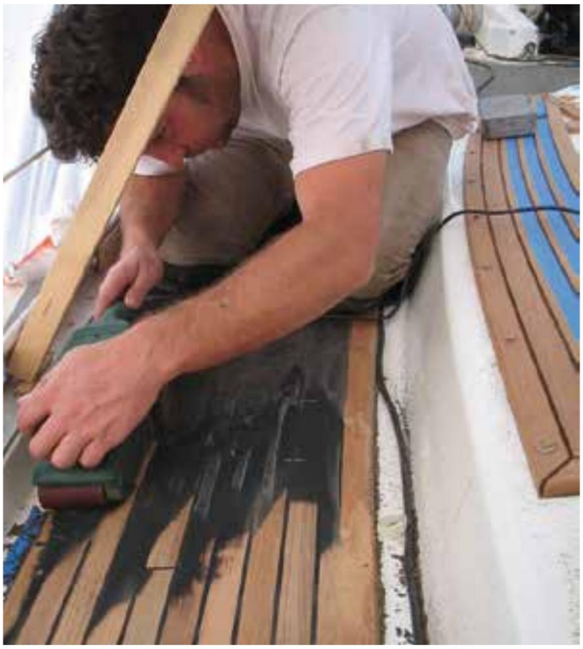
Sand me timbers!

Boatyards are very keen to do this work for you, and why not? Next time you see the boat it will look great and they know you'll be back, because soon the caulking will start to roll out in long spaghetti-like strips and the plugs will fall out, exposing the screws and making water ingress all the more likely.

Now you've really got a problem.



Even old-style decks can have their problems. Here, to avoid butt joints, the planks had been scarfed together and, after many years, the feathered edge started to lift. The owner simply fixed it with epoxy



New decks get sanded to make everything look nice and flush – but it's not a good idea to repeat this too often

The plugs are not too much trouble, but there will be hundreds to do. The real problem is the caulking. Just because some of it comes out really easily does not mean that it will all be like that. No, some of it will be sticking just like the manufacturer intended. You can make a special scraper to remove it but inevitably you will slip, damage areas and, even worse, you will enlarge the groove.

If you're really lucky you might be able to use a router for about 35% of the deck, but routers are vicious and it's all too easy to make a mistake. Even a small enlargement of the slot will look terrible. Not only that, but you'll need a curved guide to run the router along for each slot. This takes ages. Bad enough if you're doing it yourself, but it's unbelievable if you're paying a yard. Specialist tools exist but they are hideously expensive, and it's only the specialist yards that are likely to have them. Unfortunately the yard will be charging by the hour, and there's always a lot of work on any teak deck.

So what are the options now that your deck is worn out? You can't just remove it, because underneath it will be horrid. If it was laid properly in the first place they will have keyed in the glued surface, and that means taking to it with a grinder on a plastic boat. And you'll still have to cover the decks to hide the mess.

So I hope you can see that I'm advocating care and prevention for your lovely teak deck. To just leave it uncared for is an outrageous waste of a precious resource. If that isn't enough to make you care for your deck, then consider the cost of replacement. Teak costs approximately £3,000 a cubic metre, but you'll need a lot more than you think, because just cutting down a big plank to size wastes a hideous amount of wood.

The cost of the teak is a large part of the final bill. Basically, you can quadruple the price of the teak to take into account the cost of first measuring and photographing the original deck to ensure everything fits properly, the cleaning up of the surface underneath and finally replacing the wood. To do the job properly you may have to remove the chainplates, and that means dropping the mast and completely readjusting it afterwards. Not only that, but all those deck fittings that haven't been touched for years will need to be removed. And don't be surprised if many of the bolts are hell to get out or break in the process. It's possible that some of the bolts were made specially or have been glassed over. You'll need somewhere to do all this. Perhaps it's possible to make a good cover, but even this adds to the cost. The alternative is to put the boat in a shed somewhere. Anything is possible, but it always costs. Replacing a teak deck is a massive job. To replace the decks on a 9m (30ft) boat is six weeks' work – three months for a 15m (50ft). We are talking about many thousands of pounds and your boat out of action for a while.

There are other considerations before you decide on a teak deck. They weigh more: the caulking is surprisingly heavy, not to mention the wood and the thousands of screws. Perhaps what worries me most about laid decks on glassfibre boats is that you have to make thousands of holes in an otherwise perfectly waterproof surface to hold the deck down. Many glassfibre boats' decks are balsa-cored – that is to say, the deck is made of two layers of glassfibre with a layer of balsa wood in between. Balsa wood will not last long if it gets wet, yet this strikes me as very likely. The law of averages suggests that if you make 2,000 holes in a deck, the chances of them all staying waterproof for years on end is pretty slim. What happens when the balsa has rotted away? I just don't think making thousands of holes in a deck is wise. It is possible to lay a teak deck without screws, but it takes longer and therefore costs more.

So, let's sum up and cover up

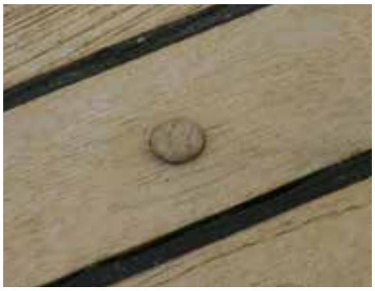
On the one hand I am thankful for owners and their teak decks since they allow me the life I lead, but on the other I am sad at the waste of it all. People could save themselves a lot of time, inconvenience and money if they just took care of their decks – and for some reason no one wants to spend money on 'posh' covers to protect their boat.

Covers are initially expensive, but they will repay their cost several times over. Not only will you not be required to replace your decks, but you'll be able to sell your boat for more because it has obviously been well looked after. It's not just teak decks that will benefit from protection – plastic windows, instruments and gelcoat will all last longer if kept out of the sun, wind and rain. The Grand Canyon was created by erosion from the elements. When you think like that, surely you can understand why I recommend covering up.

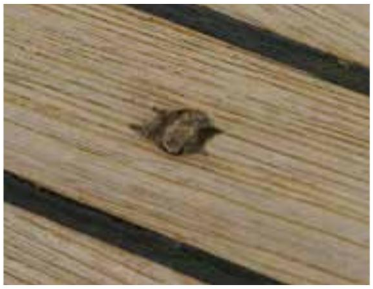
I can only do my bit. I can't change the world and I can't change fashion, but I hope I can slow down the damage by telling the truth. So now you know.

And remember: don't scrub!

THE GOOD, THE BAD AND THE UGLY

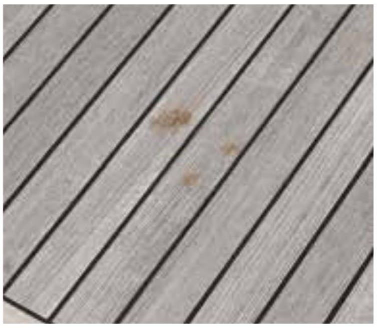


With decking that is very thin, the plugs over the fastenings are even thinner and can lift if the glue fails



This plug seems to have a problem. It could be loose and holding moisture, or the fastening is corroding

Covers over vulnerable varnished work make sense, but a complete cover will also protect the deck



Stains from oil and ferrous metal can be very awkward to remove from teak – try oxalic acid

Teak decking certainly looks good when new, but it needs to be lovingly looked after to stay that way

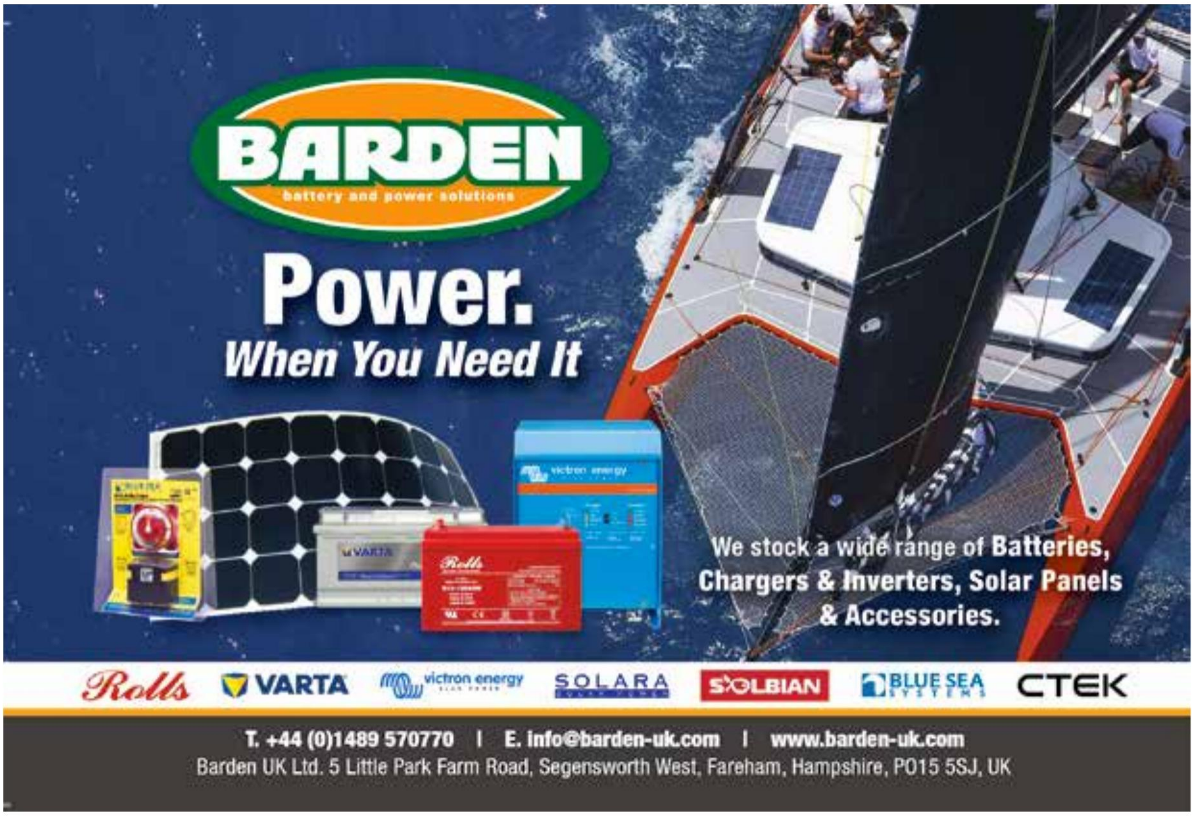
Tips for keeping teak in top condition

DO

- Wash gently once a week
- Use a light detergent and soft sponge or very soft brush
- Tackle tough stains with oxalic acid solution
- Fit a cover over the whole deck
- Repair loose caulk and plugs promptly

DON'T

- Scrub with a hard brush
- Leave decks to get really dirty
- Sand except as a last resort



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Which GLUE for which job?

Choosing the right glue for the right job on a boat can save a fortune in expensive adhesives. Richard Hare explains what is appropriate and where

Examples of adhesives that can be used on board – epoxy, polyurethane adhesive and mastic, PVA, resorcinol formaldehyde, urea formaldehyde

If you are to believe boatyard banter, you can be forgiven for thinking that no other adhesive but epoxy should ever be used aboard a boat.

In reality though, there are several types of adhesive that can be used – and sometimes at a fraction of the cost of epoxy.

Frequently they're more user-friendly too, and no less appropriate. These include resorcinol phenol formaldehyde (RF), urea formaldehyde (UF), polyvinyl acetate (PVA), polyurethane (PU) adhesives and mastics, and contact adhesive. They each have their distinct advantages and limitations, and so long as we're aware of their limitations – and that they all have them, even epoxy – we'll be fine.

There are two Standards for wood adhesives that concern us – BS EN 301 ('structural' adhesives) and BS EN 204 ('non-structural' adhesives).

Jobs like hull building and structural bulkhead construction should be done using structural adhesives, whereas most internal joinery and woodwork (non- and semi-structural situations) will be fine with non-structural glues.

Structural adhesives

Structural adhesives are the only ones that should be used for structural, all-weather applications like hull construction, structural bulkheads and below the sole (bilge area)

EPOXY

WEST SYSTEM
105
EPOXY RESIN
WEST SYSTEM
206
HARDENER

Two widely-available proprietary brands of epoxy: West System and SP

Epoxy is supplied in two parts, resin and the hardener. These are usually mixed 5:1 or 4:1 (depending on product), a job made easy courtesy of dispensers or calibrated mixing tubs. This basic mix can be used to make joints, laminates, and for waterproofing surfaces.

Degreasing before gluing is certainly recommended for oily species like teak and iroko and although companies like Gurit (SP) and Wessex Resins (West System) offer their own degreasing products, you can also use acetone or cellulose spirit.

One of epoxy's strengths is its gap-filling capability when microfibres (the white fluffy stuff) are added. Mixed to a stodge, the adhesive can then overcome all manner of amateur joinery shortcomings, making it a great product for folk like myself.

Structural adhesives should always be used below the sole and anywhere in the bilge. Here, epoxy and screws secure bearers in place. In 'filled' (thickened) form it is ideal for less skilled woodworkers as its gap-filling properties overcome joinery shortcomings

APPLICATIONS: Epoxy sticks particularly well to wood and is impervious to water. It also sticks to GRP, and metal so long as it isn't galvanised. It is, without doubt, an immensely strong and versatile adhesive. Modern cold-moulded wooden hulls are an ideal application, and it is often used with special cedar or Oregon pine strips. This is then usually cross-laminated by thin veneers, also bonded on with epoxy. The whole lot can then be overlaid with laminates of woven mat bedded in rolled-on epoxy to yield a strong, lightweight, warm and watertight hull. Increasingly you hear of epoxy being used as a primer for varnish, although its lack of flexibility might be an issue to keep an eye on.

Filled epoxy can also be used to produce filleted 90° joints between plywood panels.

LIMITATIONS: Epoxy is a structural adhesive used routinely both above and below the waterline in boat construction, but it has its limitations. For a start, it won't pass BS EN 301's boil test. It's tempting to say that since 'boiling boats' is virtually irrelevant to the leisure marine industry we shouldn't worry about this, but there are some heat-related issues that shouldn't be ignored.

Epoxies begin to lose strength at

temperatures that would not affect some other adhesives. One manufacturer said that this starts at about 80°C, another suggested a figure a little lower.

Plainly this is never going to be an issue in below-waterline situations, but it's something to consider if taking your boat to the Mediterranean or the Middle East, where radiant heat can be particularly strong. The biggest danger is when we repaint our boats. So long as we avoid overcoating with paints that become hot (dark blue being notoriously hot) it ought to be fine. My own boat has its plywood cabin and side decks sheathed in epoxy, overcoated with two coats of white two-pack PU paint.

Epoxy is also adversely affected by UV, but overpainting is the simple answer.

Epoxy is prone to stimulate allergies, so it's sensible to have a tube of allergy cream handy, use gloves and work in the open air wherever possible. But for the overwhelming majority of us it needn't be an issue.

Another problem is that it is particularly sensitive to humidity and temperature while curing – something to consider when working on boats out in the open at chilly times of the year. So long as we don't apply it in rain or in temperatures lower than 10°C within the next 24 hours, we ought to be fine.

Epoxy retains its greyish appearance once cured, but this can be altered by adding wood dust for more of a matching finish.

RESORCINOL PHENOL FORMALDEHYDE (RF)

RF is a structural water-based adhesive to EN 306 which is so tough that you can boil it for hours with no real detriment. In former BS days it was classified as weather- and boil-proof (WBP).

A synthetic resin, RF has been used routinely for boatbuilding since the middle of the 20th century, and although its monopoly has since been broken by epoxy it is still used today. My own boat was built in the 1990s, much of it with RF.

Given its age, this classic teak-planked yacht will almost certainly have RF glue used in appropriate areas of its construction

Several manufacturers produce this performance-proven adhesive for fully exterior and below waterline yacht construction, but Extraphen (now renamed Polyproof) seems to have monopolised the DIY end of the market. Dynea UK, manufacturer of Prefere (formerly Aerodux) tells me that it is also now developing the consumer end of the market through its distributors Alansons Industrial Supplies. Wessex Resins and Adhesives supply Cascophen.

Historically, the mixing of resin and hardener powder has been done on a weight basis, a feature of it that tends to put off amateur users. But Alansons now say you can mix Prefere liquid/liquid components on a volume basis.

POLYPROOF
WATERPROOF GLUE
POLYPROOF
WATERPROOF GLUE

Resorcinol formaldehyde is water-based and ideal for a fully exterior structural bond. It has poor gap-filling capability but is great for laminating

APPLICATIONS: RF is great for laminating and veneering things like keels and rudder foils. It is a wood-to-wood adhesive for interior and exterior use, is weather- and boil-proof once cured, and joints made with it are resistant to micro-organisms, UV light, weather and steam.

LIMITATIONS: A problem with RF is that it doesn't have any real gap-filling capability, and certainly nothing remotely like that of filled epoxy. Amateurs can use it, so long as they make a proper tight joint with good contact.

Another slight disadvantage might be its dark colour. Splashes and joint oozing can be cleaned up quickly with water, but the dark glue line remains when it has cured. Like epoxy, it cannot be used below 10°C.

POLYURETHANE MASTIC

Mastic PU adhesives (as opposed to foaming non-mastic PUs) like Sikaflex, Nail and Seal from Evo-Stik, Soudaflex (distributed through Alansons) and the new competitively-priced CT1 have exceptional strength and good gap-filling properties. Historically, they have been expensive – although their recent emergence in builders' yards has done quite a lot to focus minds on keener prices.

They are highly resistant to UV, high temperatures and water.

Since no catalysts or solvents are involved they are also compatible with foam materials. As such they can be used for bonding insulation into engine boxes, and insulation to GRP and metal hulls. They can also be used to bond surfaces like Treadmaster.

PU mastics like Sikaflex 291 (top), Evo-Stik Nail and Seal (above), Soudaflex and CT1 are particularly good for bonding dissimilar and uneven materials

PU mastics tend to cure quickly, which means cleaning off excess needs to be done rapidly. Cellulose spirit is a cheap off-the-shelf solvent that works well.

PU mastics retain their colour once cured and are used extensively for applications like the caulking of teak decking. It has also been used as a high-tech alternative for caulking carvel hulls.

APPLICATIONS: PU mastic is excellent for bonding dissimilar materials – wood to metal, plastic to GRP and foam to GRP, for example. It can be used above or below the waterline. It's good as a bedding material below stanchions and other deck fittings as it seals as well as sticks.

LIMITATIONS: PU mastics cure quickly and are messy to clean up. Masking the area is a good way of keeping this to a minimum. They also have a short pot life once opened. Nozzles seize up, and it may be that the only way to access the dollop within is by cutting open the side of the tube.

Because these adhesives are so effective, and gap-filling too, you need to think carefully about using them as a bedding mastic for deck fittings and suchlike. Sod's Law says you will eventually want to remove or replace said fitting – and you may rue the day you used PU mastic. That said, it will keep the water out like nothing else.

...STRUCTURAL ADHESIVES CONTINUED

POLYURETHANE ADHESIVES (PUs)

Polyurethane adhesives, like these Balcotan products aimed at the marine market, are a good choice for wooden mast repairs and scarfs

PU adhesive foams as it cures, so is ideal for filling small gaps. It will probably be necessary to clamp or screw the pieces you're joining

Polyurethane glue (not mastic) is solvent-free, single component and waterproof. Until 2005 these adhesives did not meet the criteria to be classified as structural adhesives to BS EN 301 – but then along came the 'single shot' Balcotan polyurethane SuperFibre 60 190, which does.

Balcotan 60 190 is simple to use: apply it to one side of the joint (with a 1-2mm serrated spatula), clamp up the components for the curing time, let it foam and then remove clamps when the cure time is up.

Until such time as other PU adhesives are tested for compliance all you can say is that this type of glue, as a whole, is likely to meet the 'non-structural' BS EN 204 standard.

Balcotan's standard PU adhesive is recommended for use in exterior applications in cold and damp conditions, and it is reported to have been chosen for gluing the laminates of sledges used by the ice patrols of northern Greenland as well as structural glue-laminated beams of ice skating rinks, and road bridges in Switzerland. It has a massive temperature tolerance once cured (-30°C to +200°C).

APPLICATIONS: The gap-filling (foaming) capability of polyurethane adhesive makes it a good choice for mast repairs and scarfs. The fact that it foams is also an appealing factor when producing foils.

An advantage of PU is that it is relatively unfazed by moisture. Here, it scores well over the humidity-sensitive epoxy.

PUs are moisture-curing and use the humidity in the air and the moisture in the wood to activate the curing process, without diluting the glue or damaging the adhesive properties. Its ability to stick to wood with up to 25% moisture content (MC) makes it useful for hull repairs. This is a lot higher than the specified MC of other adhesives reviewed here.

It is important to clamp or otherwise restrain joints while they cure. Pins and screws can do the job if they're snug.

Excess material, once cured, can be sanded or chiselled away easily, and the glue line is virtually invisible. Uncured material can be cleaned off with acetone.

LIMITATIONS: Although the foamed adhesive fills voids nicely, looking a bit like an Aero chocolate bar, it doesn't maintain its strength to the same level as when it's compacted. The recommended minimum working temperature is +5°C, with 80% humidity. Rapid formulations cure in 30-60 minutes with an open joint time of 10-15 minutes, whereas regular products cure in 3-6 hours with a 75-minute open joint time. Products with superior gap-filling are available (fibre gels), and these come courtesy of added fibres. Foaming excluded, they claim to bridge gaps of up 1.5mm.

WHICH GLUE IS BEST FOR WHERE?

Adhesive type	Suitable for/skill level:	Not ideal for:	Cleaning-up solvent:
Epoxy	Structural/exterior/waterproof. Below waterline/sole. Amateurs and professionals. Easy mixing on site	Allergy sufferers. Cold/damp during application. Very high temperature situations and UV in use	Proprietary, or cellulose spirit or acetone
Resorcinol phenol formaldehyde (RF)	Structural/exterior/high hazard to EN 301. High temperatures. Below waterline/sole. Skilled amateurs and professionals	Low-skilled amateur joiners. Mixing ratios by weight can be difficult. Cold during application	Water
PU mastic	Structural/exterior/high hazard. Bonds many dissimilar materials. Below waterline/sole. Amateurs and professionals	Expensive for wood/wood joinery	Cellulose spirit and acetone
Polyurethane adhesive (PUs)	Both structural and non-structural/exterior/low hazard. Claimed to be totally waterproof and compatible with wide temperature range. Professionals and amateurs. No mixing needed	Needs clamping/screwing restraint while curing. Potentially high strength situations	Acetone/cellulose spirit
Polyvinyl acetate (PVA)	Non-structural/exterior/low hazard (weatherproof). Cabin interior above sole. Limited exterior exposure (standard) provided 'adequately protected'. 'Weatherproof' better suited. Professionals and amateurs. No mixing needed	Cold/damp during application. Prolonged warm/moist conditions in use (standard). Unprotected external use (weatherproof)	Water
Urea formaldehyde (UF)	Non-structural/Interior/low hazard. Cabin interior above sole. Limited, intermittent exterior exposure. Professionals and amateurs. Easy mixing on site	Prolonged warm/moist conditions	Water
Impact adhesive	Non-structural fabric to wood; leather to metal; foam to ply and GRP	Wood to wood. Polystyrene	Proprietary

BS EN 'Exterior' sub-grades: High hazard = full exposure to weather. Low hazard = exposed to weather but protected from sun and rain.
Note: This table is for guidance only. Consult suppliers for detailed information.

Non-structural adhesives

There are several low-cost adhesives that can be used perfectly safely for interior joinery. These include urea formaldehyde (UF), polyvinyl acetate (PVA), non-structural polyurethanes (PU), and impact adhesive

POLYVINYL ACETATE (PVA)

EVO-STIK
WOOD
adhesive

PVA is available in small quantities, and in weatherproof and non-weatherproof versions

PVA is a non-structural, water-based glue which is also available in a 'weatherproof' formulation. Like UF it's cheap and, being water-based, is extremely easy and pleasant to work with.

When fitting out my Golden Hind, *Keppel*, I used it extensively for bonding iroko trim to locker doors as well as securing maple strips to the plywood floor panels. In both cases, brass panel pins were used as well. Eight years on? No problem, even in the Med. It is not suitable for load-bearing and structural situations.

PVA manufacturer Bostik (which sells under the Evo-Stik brand), explained that even ordinary PVA would be fine for interior yacht fitting out as it only begins to weaken if it becomes soaking wet. The wood itself provides a high degree of protection, and by the time we've applied a few protective coats of varnish, we're pretty much home and dry. Indeed, if a boat's interior becomes so wet that our decorative trim is coming adrift we'd have infinitely more serious things to worry about. Launching the liferaft, perhaps?

Personally, if using PVA I'd recommend the weatherproof formulation. This differs insofar as it has added metallic salts that make the glue cross-link in addition to the evaporation cure. The company explained that it's good in a continually wet environment, but not in a situation where it is to be permanently immersed. If that doesn't make it safe for interior fitting out, I don't know what does. Evo-Stik weatherproof PVA sets within three minutes, with full bond strength attained after 24 hours, after which the literature claims that joints are completely protected from rain, storms, frost, snow and ice.

APPLICATIONS: Although weatherproof PVA can be used externally it is not a structural adhesive and can therefore not be used for structural boatbuilding. It is fine, though, for numerous interior joinery applications.

Being clear when cured, it's a useful adhesive for use with light-coloured woods.

LIMITATIONS: None really, so long as you don't use it externally and structurally. Standard PVA should not be used externally at all.

IMPACT ADHESIVES

EVO-STIK
IMPACT

Although not a wood adhesive, impact or 'contact' adhesives ought to be mentioned. Impact adhesive is applied to both surfaces, allowed to dry for about 10-15 minutes, and then the two surfaces are mated. You don't get a second chance – once they come together, that's it.

APPLICATIONS: Impact adhesives are used for jobs like bonding Treadmaster to decks, and engine insulation to engine boxes. They can also be used for all sorts of jobs like bonding leather protection to alloy spars (whisker poles etc), fabric and reinforced vinyl. It's handy stuff to have, but you'll not be building a boat out of it. While standard builders' merchant impact adhesive can be used with Treadmaster, the company's own proprietary product really does perform better. Ordinary contact adhesive can be used for bonding melamine laminates to wood-based substrates for situations like galley worktops and in the heads. It is also used for inflatable dinghy repairs.

LIMITATIONS: It's not a wood-to-wood adhesive.

UREA FORMALDEHYDE (UF)

AEROLITE
306 GLUE
Synthetic resin glue for wood

Aerolite 306, a commonly-used catalysed UF, was re-branded to become Prefere 306

UFs – products like Prefere 306 (formerly Aerolite 306) – often come in for flak when it comes to boatfolk banter.

A common notion is that it loses its strength after about 20 years. Not so, apparently. Although it certainly isn't recommended for hull construction, Aerolite manufacturer Dynea UK claims that test pieces in the lab, laminated up 40-50 years ago, are still being tested to destruction and show no appreciable signs of deterioration. Meanwhile, the marketing literature claims it to be 'water and heat resistant'. Be mindful of the word 'resistant'.

Catalysed UFs like Prefere/Aerolite 306 are claimed to be fully cross-linked and irreversible once set. With 'slow' catalysts it can be used down to 15°C, but with 'fast' hardeners it can be used down to 10°C. Non-catalysed products like Extramite, which cure by evaporation alone, may differ.

APPLICATIONS: Useful for bonding wood to wood below decks and above bilges, it's also fine for semi-exterior applications like cockpit tables that are normally stowed away in the dry. Dew and the odd shower will not affect it.

Being clear when cured, it's a useful adhesive for use with light-coloured woods. It is applied to one surface only. The hardener (catalyst) is applied to the other, so a pot can be made up and used all day, maybe more.

LIMITATIONS: Not only is UF unsuitable for long-term exterior use, but it is also susceptible to hydrolysis – a form of degradation that occurs in very warm, damp or humid conditions – so it's best avoided in boats destined for equatorial regions where humid conditions can be expected.

For most of us, though – in temperate climates and the Med – it seems that you can continue to use UF with confidence below decks in many semi- or non-structural applications. Its low cost, a pot life that goes on for days and a disinclination to cause allergies make it an attractive alternative to epoxy. Oily species like teak and iroko benefit from degreasing with something like cellulose spirit or acetone, for optimum bonding.

UF has a greyish appearance but it becomes quite clear when cured. Gap-filling properties aren't so good.

SUPPLIERS

- **Dynea UK Ltd (RF and UF), www.dynea.com**
- **Bostik Findley (Impact adhesive, PU mastic, PVA), www.bostik.co.uk**
- **Melco Bonding Supplies (PU adhesive), www.melcobonding.com**
- **Wessex Resins & Adhesives (West epoxy, RF, UF, PVA), www.wessex-resins.com**
- **Blakes (SP epoxy), www.boatpaint.co.uk**
- **Alansons Industrial Supplies (RF, UF, PU mastic), www.alansonsuk.com**

Build a switch panel for boat electrics

Unable to find a suitable, off-the-peg control panel for the electrics on his Achilles 24, David Larner custom-designed and built his own

My nephew's Chris Butler-designed Achilles 24, *Slippery When Wet*, was getting on in years and the electrical system needed a complete rewiring. This handily gave us the opportunity to fit a new control panel at the same time.

To fulfil all our requirements we decided we'd need 10 illuminated rocker switches, each with a fuse, a digital voltmeter to check the voltages of the two batteries, and a main fuse to protect the cables to the battery.

We were unable to find a suitable ready-made switch panel with all these features so I set about making, designing and building one to fit. Designing it ourselves also gave us the opportunity to customise the switch names.

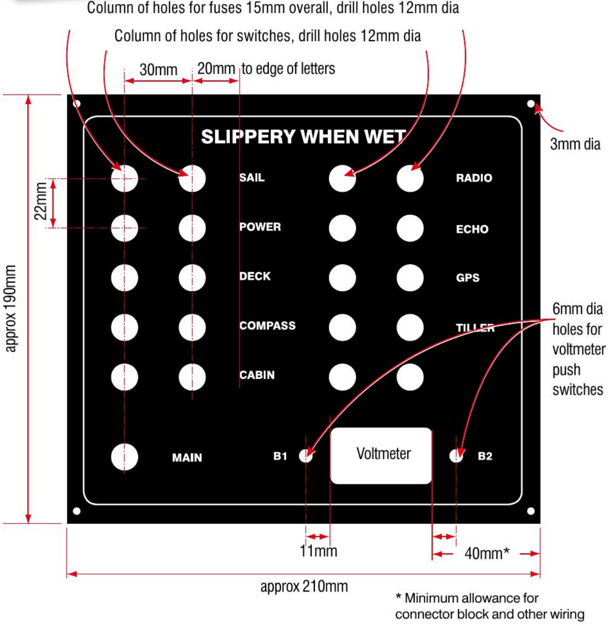
I made a preliminary drawing which we sent to Lymm Engraving of Manchester who did the final design before cutting, drilling and engraving the panel. When designing a board it's important to remember to allow space behind for connector blocks and other wiring. Switch names were kept as simple and self-explanatory as possible: for instance, Power refers to the navigation lights used when proceeding under power, Sail is for the lights used when sailing, and Tiller is for the Tillermate autopilot.

Initial assembly

To fit the connector blocks, I first roughened an area on the reverse side of the panel and attached a piece of marine plywood with epoxy glue. This gave a good hold for the screws to hold the blocks. The switches and fuse holders were fixed through the pre-drilled holes, and the voltmeter was a snap-fit into the panel.

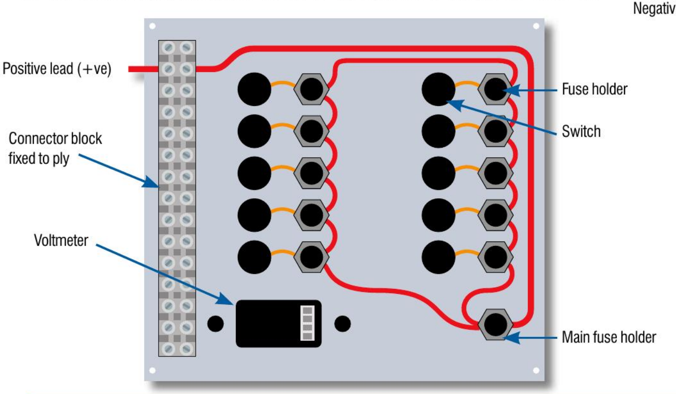
I built the wiring up in layers using flexible multi-strand wire: single-core wire is too brittle and will eventually crack through fatigue. Spade terminals were used to connect to the switches, and solder joints for the fuse holders and the press-button switches used by the voltmeter.

STEP 1 DESIGN


Column of holes for fuses 15mm overall, drill holes 12mm dia
Column of holes for switches, drill holes 12mm dia
30mm
20mm
to edge of letters
3mm dia
SLIPPERY WHEN WET
SAIL
RADIO
POWER
ECHO
DECK
GPS
COMPASS
TILLER
CABIN
MAIN
B1
Voltmeter
B2
22mm
approx 190mm
6mm dia holes for voltmeter push switches
11mm
40mm*
approx 210mm
* Minimum allowance for connector block and other wiring

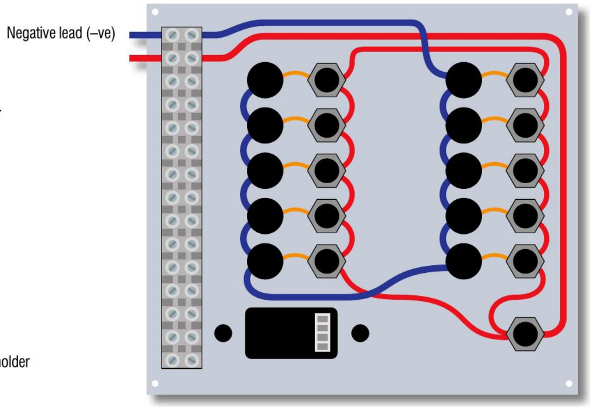
STEP 2 CONNECTING THE POWER

Here, the positive power cable is taken from the connector block to the main fuse holder and then makes a ring circuit distributing power around the individual fuse holders. Short bridging wires carry the power from each fuse holder to its associated switch – take care to leave some slack here as the central lug of each fuse holder is spring-loaded and needs to move.


Positive lead (+ve)
Connector block fixed to ply
Voltmeter
Fuse holder
Switch
Main fuse holder

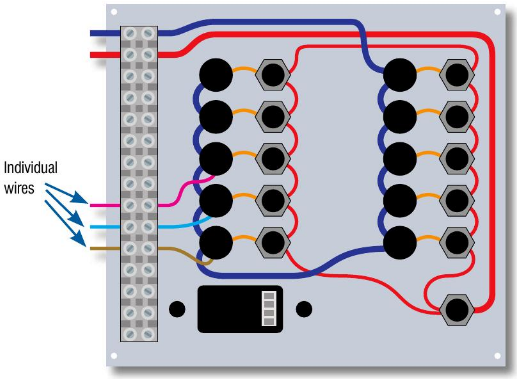
STEP 3 COMPLETING THE CIRCUIT

I then looped the negative wire between each switch back to the connector block. A good test at this stage is to apply power to the block and activate each switch in turn – they should illuminate.


Negative lead (–ve)

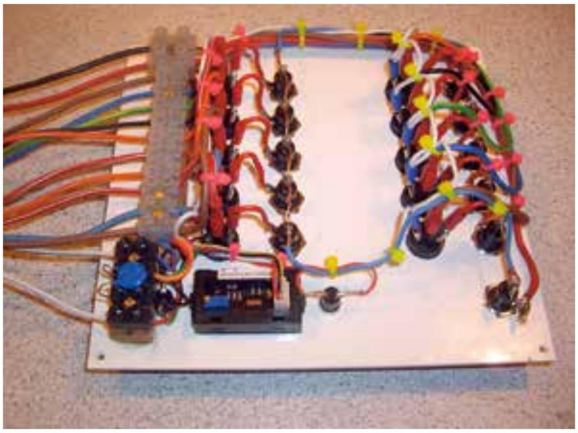
STEP 4 INSTRUMENTS AND LIGHTS

Taking individual wires from each switch to the connector block now completes the main wiring. The result is a self-contained panel which can easily be connected or disconnected via the connector block, without disturbing the boat's wiring.


Individual wires

STEP 6 TIDYING UP THE WIRING

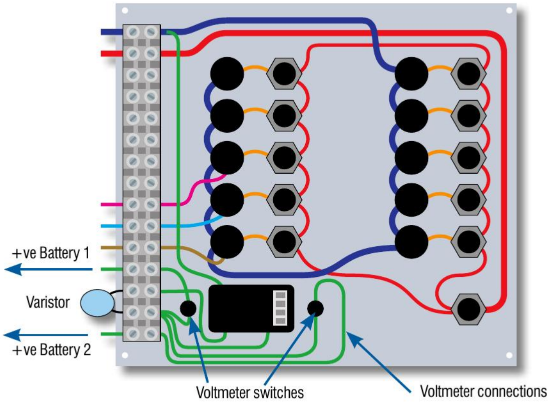
To make the wiring secure and smart, I bundled the cables together and fastened them with cable ties before trimming the ties to their final lengths.



STEP 5 CONNECTING THE VOLTMETER

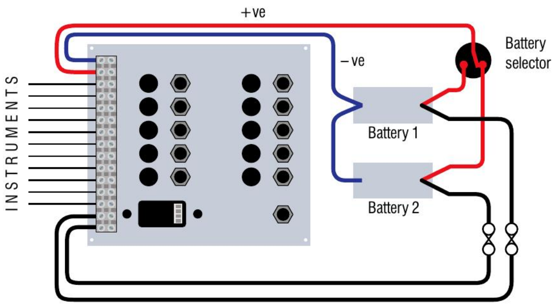
We opted to include a voltmeter to check battery voltage, which I connected according to the manufacturer's instructions using simple push-button switches to select either battery.

A varistor was recommended (blue in the photographs) to prevent current spikes damaging the electronics: this was easy to add thanks to the connector block. Varistors normally have no effect on a circuit, but in the event of a current surge become conductive, allowing an alternative current path away from the device.


+ve Battery 1
Varistor
+ve Battery 2
Voltmeter switches
Voltmeter connections

STEP 7 FINAL INSTALLATION

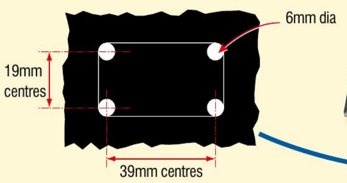
Finally, the panel was connected to the boat's system. Building the panel this way minimises the amount of time working on board – I was able to do most of the work at home.

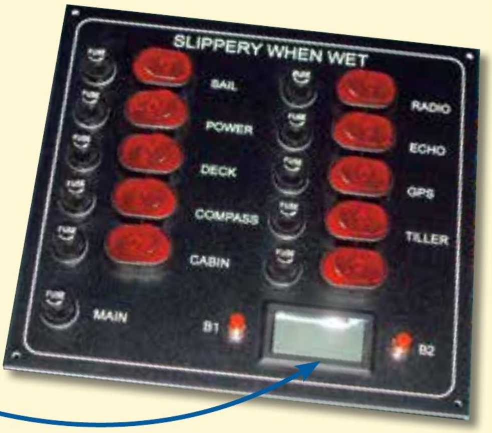

+ve
–ve
Battery selector
INSTRUMENTS
Battery 1
Battery 2

Final thoughts

My nephew and I are very pleased with the result: it is smart, has all the features we wanted with appropriate names for switches, and is even customised with the name of the boat.

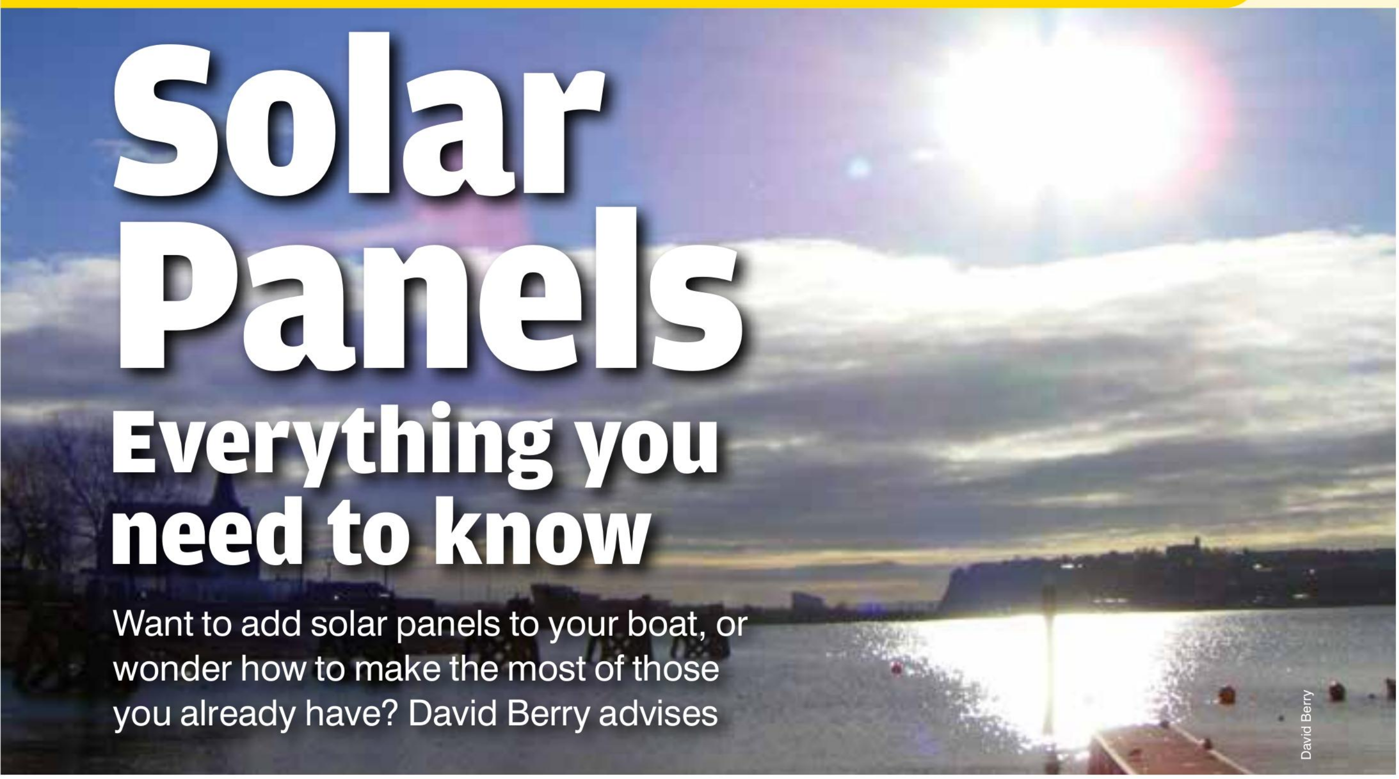
Enlarged view of voltmeter cut-out


6mm dia
19mm centres
39mm centres


SLIPPERY WHEN WET
SAIL
POWER
DECK
COMPASS
CABIN
MAIN
B1
B2
RADIO
ECHO
GPS
TILLER

COSTS

- Panel cutting, drilling and engraving: Lymm Engraving, Manchester, £34
- Switches and fuse holders: Semiconductor Supplies International, Surrey, £9
- Digital voltmeter and varistor: Conrad Electronic, Bedford, £22
- Press-button switches, connector blocks, terminals and cable ties: Maplin, Halfords, and B&Q. When buying from non-marine suppliers, try to find components with tinned terminals – these will last longer in a marine environment



Solar Panels

Everything you need to know

Want to add solar panels to your boat, or wonder how to make the most of those you already have? David Berry advises

David Berry

Keeping batteries topped up is an ongoing problem for boat owners. Is it enough to run the engine from time to time and put up with the huge inefficiency, effects on long-term engine performance and growls from your neighbours, or should you fit an independent means of charging the battery, such as a wind generator or solar panel?

Solar panels are an increasingly popular option, not just in the Med but also around the coasts of the UK as the price comes down and down. But choosing them can seem a bit of a black art: after all, how can you possibly predict how much sun you're going to get during the season, or how much power your panel will produce if it's not exactly aligned with the sun? But provided you accept a statistical approach using established databases, then prediction is easier than you think.

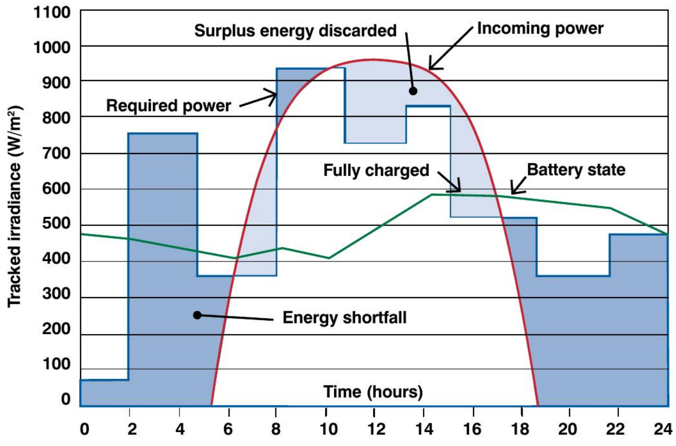
How much power do I need?

The first step is to work out your boat's power requirements. All you have to do is add up all the energy in watt-hours used by each device on your boat, such as the fridge, lights, computers and so on. Energy is power accrued over time, so if power is measured in watts, energy is watt-hours. Most of these devices will have a badge which will tell you what the power requirements are in watts, so you just multiply this number by the number of hours per day the device is actually working. When making your estimates, remember that the fridge will work harder when the sun is out and the temperature gets up.

Once you have your energy requirements worked out, I suggest you add a goodly margin for expansion and errors – at least 10%. There's a worked example at the end of this article.

Next, you need to decide how much of this requirement should be met by the solar panels. We sail our Moody 33 *Aderyn Glas* throughout the summer season from our base in Preveza, Greece, so our requirements are essentially those of liveaboard sailors – we want the panels to be able to supply most of our power needs and allow us not to have to ruin the peace of a quiet anchorage by running the engine just for charging, while weekend sailors might be content with a small panel to recharge, over the course of a week, the energy used during a day's sailing.

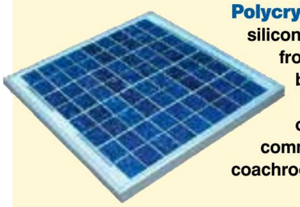
Getting the balance right is important, especially if you're looking to install enough solar panels to more or less cover your power requirements. To do this you will need to calculate how much power you can reasonably



A HYPOTHETICAL ENERGY BALANCE. The red line is the clear-sky power that the panel could provide during daylight. The blue line is the power your boat requires. Light blue is surplus energy, where the panel is outputting more than the load, and dark blue is where the load is greater than the panel can deliver. When night falls, the boat's energy needs have to be met by the battery. In daylight, the battery becomes a load for the panels as it is charged. The green line is a notional illustration of the state of the battery; it winds downwards when there's a shortfall and upwards when there's a surplus available for charging. In winter, the load profile will be different and the captured power will be lower.

TYPES OF SOLAR PANEL

Amorphous panels are made by depositing silicon onto a substrate. This process is cheap and allows flexible panels to be made relatively easily, but large areas are needed to generate much power. This effectively puts the price up. However, amorphous panels are tolerant to low light levels, so they can be a good choice.



Polycrystalline (or multicrystalline) panels use small pieces of silicon fused together, making panels look like they are made from metal flakes. They work well in unobstructed sunlight, but if even one of the silicon cells is shaded the others try to feed power into it, dramatically reducing the overall efficiency of the panel. Semi-flexible panels are commonly available, which offer enough curvature to fit a coachroof, for example.

Monocrystalline panels use large individual pieces of silicon for each cell. They are generally now the cheapest solution and the default point to start from when planning an installation. Semiflexible panels are available, but are rare owing to the fragility of the single crystals. They are just as affected by shade as polycrystalline panels

expect to get from your panels over 24 hours – more of this later – and ensure that the panels are powerful enough to supply your complete power requirements in the daytime, plus have enough capacity to charge the battery by the amount it has been depleted overnight. If you underestimate this you will end up having to run the engine to top up the batteries every so often; overestimate and the solar panel's regulator will be throwing power away.

But will you get the quoted wattage from your panel? If the panel is a 100W panel, will you get 100W? Panels are rated as the electrical power produced under certain strict test conditions, and these are solar irradiation (called insolation) of 1,000W/m^2 at 25°C and an atmosphere of a particular clarity. Do we ever get these conditions in practice? Well, yes, we do, but life is never that simple – and later I'll explain about how to assess the real insolation over the course of a day in your chosen location.

What kind of panel should I fit?

This question is a bit of a red herring – in reality, the question should be 'How much space do I have?'

There is now a whole taxonomy of solar panels comprising three generations and various species within each generation. The academic drive is to make panels that are more environmentally friendly, both to make and dispose of, and to reduce the cost per watt. But this has resulted in a much poorer conversion efficiency (the amount of electrical power you get per watt of solar power), which is not helpful to sailors with a small area available to mount the panels. Because of this, let's eliminate from this discussion the third-generation organic panels, however creditable the motives for developing them. Similarly, second-generation amorphous panels have, in my opinion, little to recommend them: although they are cheaper to manufacture, the cost per watt by the time they sit on the shelf in the shop is two or three times the cost per watt of the first-generation crystalline panels. Their only obvious advantage is their tolerance to shading. So, back to the first generation: crystalline panels come in mono- or polycrystalline species, but they only differ slightly in cost per watt and efficiency.

Added to the mix is the flexibility aspect: flexible panels require a bit of clever manufacture, and this is passed on in higher prices. So does this mean the default starting point for any installation is a rigid, crystalline panel? In short: yes!

Where should I put my panels?

If you're just fitting a small panel to top up batteries on a mooring, buy a cheap rigid panel and find places on your boat where you can tilt it to catch the sun's rays for the majority of the day. We do this during the winter in Greece, where we strap an old 15W amorphous panel to the coachroof, and it works well for us. It's not heavy, and a crystalline panel would be smaller and thus lighter. Choose a spot that isn't shaded for the majority of the day and this technique should serve you well. Do the sums. I have heard of people whose batteries have been damaged by a constant high power being applied to an already charged battery, even through a regulator. My rule of thumb for trickle-charging is a panel wattage about 10% of the battery's stated amp-hours.

If you spend more time on board and need to get the best from your panels, mono- or polycrystalline panels will give more power from the same space – we replaced our 75W bank of amorphous panels with 200W of monocrystalline panels in the same area. But with higher efficiency comes higher sensitivity to poor mounting conditions, so if you want the best from your panels you need to do your utmost to ensure they are not shaded, and also that they are tilted as close to a right-angle to the sun as possible. For this reason, liveaboards usually mount theirs on gantries at the stern or on the pushpit.

ADERYN GLAS

David Berry

Aderyn Glas **is fitted with two monocrystalline panels which are rated at 100W apiece – they take the same space previously occupied by amorphous panels which could only muster 75W between them**

Specifying your system

Once you've totted up the energy in watt-hours you need to provide to keep the beer cool and the tablet charged (and to supply enough spare for your crew's pedicure set and hairdryer), and looked around your boat to find a suitable mounting site which is close to the battery bank but completely free of shade, you effectively have a set of criteria that you would like your installation to meet. Now it's time to look at the limitations of the technology, and see how close a match you can get to your required performance.

Intrinsic losses

Let me just revisit this: the relationship between the nominal power of a solar panel and what you really get. When the manufacturer quotes, for example, 100W for a panel, that is the expected output under test conditions. The test conditions are an insolation of 1,000W per square metre at 25°C.

So if you get a sunny day that insolates your 100W panel at $1kW/m^2$ then you have the potential to get 100W output for a short time around solar noon. But the energy over 24 hours will be below this owing to the declination of the sun over the course of the day. This can be partly remedied with a tracking panel, but as the sun declines the light has to pass at a more oblique angle through the atmosphere, hence losing power. The insolation will also be affected by your latitude, and by any form of shading or scattering from atmospheric dust, haze or cloud.

Another important intrinsic loss is that heat reduces a panel's output by about 5% for every 10°C rise in temperature greater than 25°C. For this reason, it's quite possible to get a higher output from a solar panel in cooler northern latitudes than on the Equator! Other panel losses you should be aware of are shown in the table below.

There is a tolerance on the nominal value quoted. I've seen figures of +/-3% from one manufacturer and +5% from another (which is good, of course).

Over life, the panel output will decay. A crystalline panel will lose about 10% in 10 years. Please don't write in about the low efficiency numbers – I know the panels will give better than this (actually, I know the panels will achieve their rated power output under the right conditions, so efficiency is only of academic interest), but if you want details of panel technology efficiencies and how they have improved, have at look at the US National Renewable Energy Laboratory's really interesting diagram here: http://energyinformative.org/wp-content/uploads/2013/08/efficiency_chart.jpg.

Choose your site carefully – this coachroof panel will be shaded by the boom, reducing its output

Sarah Norbury

INTRINSIC LOSSES

Watts	Cost £	W/m^2	£/W	Efficiency %	Technology
250	180	151	0.72	15.15	Polycrystalline (household)
100	100	153	1	15.38	Monocrystalline
100	148	148	1.48	14.85	Polycrystalline
100	183	153	1.83	15.35	Monocrystalline
100	200	130	2	13.05	Polycrystalline
100	250	148	2.5	14.89	Monocrystalline
75	192	149	2.56	14.91	Polycrystalline
100	385	176	3.85	17.64	Semi-flexible monocrystalline
130	516	127	3.97	12.75	Polycrystalline
15	90	35	6	3.51	Amorphous
65	498	121	7.66	12.18	Semi-flexible monocrystalline
68	745	131	10.96	13.18	Semi-flexible monocrystalline
70	815	128	11.64	12.89	Semi-flexible monocrystalline

So you see what I mean when I say the question is all about how much space you have: the default option should be a crystalline panel because it has the best watt per unit area coupled with price per watt, and we only need to deviate from this simple first-generation solution if other factors are important.

Amorphous panels need four times the area per watt than crystalline ones and cost about twice as much per watt, and when you go flexible the cost spirals upwards exponentially.

Other system losses

CABLES Losses in cables are proportional to the square of the current. The equation is $P=I^2R$ where I is the current in amps, R is the resistance in ohms and P is the power in watts. The voltage gradient from the high voltage at the panels to the lower one at the regulator is fixed by the cable resistance and current (Ohm's law), which is in turn set by how sunny it is and the power required, but the resistance is a matter of design. To minimise cable losses (and prevent potential overheating cable problems), large-core cables are needed. Resistance is also proportional to the length of the cable, so long cables need to be even fatter than short ones.

SHADING

Of all the possible ways to lose power from a panel, this is the most important. On a crystalline panel, even the stripe of a rope's shadow can wipe out a huge amount of the potential output power. We've had situations where the shadow of our neighbour's mast in port has robbed us of most of the power we could have achieved, and we've even had to move our ensign from the backstay because its fluttering shadow took the power output down. Why is this? The individual cells in a crystalline panel are wired in such a way that a cell which is in shadow and not producing will act as a sink for the power produced by the other cells it's wired to, with the result that virtually no power escapes from the panels as a whole. So a shadow that covers perhaps 10% of the panel might be enough to zero its output completely. In contrast, the more expensive amorphous panels will lose only perhaps 10% of their output, which, as I've said elsewhere, is their only advantage.

MAXIMUM POWER POINT

The rating from the manufacturer is quoted as the best possible output irrespective of the voltage needed to get that output. As a typical example, you might find a 120W panel delivers 7.1A at 16.9V, thus giving 120W. But to use this power you have to be able to operate at 16.9V. There are regulators that do this (see MPPT types, below) and these are becoming more accessible to thrifty sailors as time passes.

REGULATOR

The job of the regulator is to throw power away. It does this to ensure the power passing on to the batteries or services is not too great for them to handle. Normally it does this by controlling the amount of power passing through it to hold the output voltage at some predetermined value such as the float charge voltage of 13.4V. The value of the power it passes depends on the current required by the load: the sum of batteries, lights, fridge and so on that are sucking the current from the panels. If the fridge is on, for example, more power will flow through the regulator and it will throw less power away as heat.

Most common, older regulators use a pulse width modulation (PWM) system which is more efficient than simply controlling the output voltage. Maximum power point tracking (MPPT) devices provide more usable power by seeking the panel's optimum power voltage, and in recent times the cost of these devices has fallen dramatically so that they are now worth serious consideration.

When I wrote the first version of this article in 2011 I recommended that since MPPT regulators were so expensive it would be better to spend the money on slightly larger panels, but with the change in pricing of regulators and panels this is not such a clear-cut option, and now I would suggest using an MPPT regulator such as a Victron 75/15 (which can be bought for under £100) rather than the older PWM type. The PWM regulator needs to operate at about 15V input to give the required 14.4V output, and at 15V the panel suffers a power loss compared to the maximum power point of around 10% to 33%. I investigated the effect of fitting an MPPT regulator to *Aderyn Glas*, and my report was published in PBO January 2015.

To the solar panel, the regulator is part of the load – a consumer of power – which is why the entry to the regulator is an appropriate place to measure the voltage and current if you want to see exactly how much is being generated by the panels.

How much power do I really get from my solar panel?

If you do the sums, the unavoidable losses on a new panel operating at 65°C are typically 40%. Our example 100W panel is therefore only putting out 60W, and that's only for a few hours. If you really need every scrap of power then you need to find a way to keep the panel cool, and you need to invest in an MPPT regulator. As the panel gets older its performance will drop off even more. All a bit depressing, isn't it?

I have to say, though, that in our particular installation on *Aderyn Glas* the output is better than theory would suggest. We regularly get more than 10A from our 200W panels, and our highest recorded value was 170W, which suggests that these loss figures are conservative.

The reality seems to be that with a well-set-up installation you can expect to get a maximum of 75% of the power you would expect from a continuously insolated panel operating at its rated power.

Insolation: or how much power is reaching me?

The sun is 93 million miles away, give or take. Packets of energy called photons leave it and travel at 186,000 miles per second just to fall on us and keep us supplied with energy. If you held up a solar panel outside our atmosphere, it would be irradiated by broad-spectrum sunlight at 1,370W/m^2: this is called insolation.

Because the Earth is tilted on its axis, we see more of the sun in the summer than the winter: in the winter it just about creeps above the horizon, and the stream of photons has to travel through a far longer atmospheric path than when it is overhead in the summer.

At sunrise and sunset, the atmospheric path length is about 11 times the noon path length. The longer the path length, the more of the sun's energy is lost by atmospheric absorption and through scattering.

Latitude is the other great influencing factor. If you were sitting at the North or South Pole, the atmospheric path length would be almost constantly 11 times as long as the path length above someone sitting on the equator. A useful mathematical model is available at http://pvcdrom.pveducation.org/SUNLIGHT/SHCALC.HTM.

Can an angled panel help me catch substantially more power?

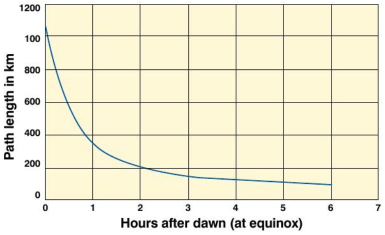
At solar noon, the horizontally-mounted panel performance will get as close to the panel on a tracking mount as it will ever get. However, as the sun declines the power drops off rapidly. The graph (below) shows how the irradiance of a horizontal panel varies as a percentage of the irradiance of a tracking panel. I mounted the panels on *Aderyn Glas* on a tilting mount so that I could track the sun in elevation but not in azimuth. This is a compromise: if you cruise a particular latitude and can tilt your panels to the optimum angle for your latitude, and track the sun in azimuth from east to west, you will get much more from your panels. Suitable mounts such as the Altazimuth two-axis mount are available, but it may be better to spend your money buying bigger panels and settling for a more modest mounting arrangement. We just try to swing *Aderyn Glas* to track in azimuth – but of course we can't always do so.

An alternative is to mount your panels at a fixed angle so that they are permanently tilted and do not track the sun at all. Again, this is better than a horizontal panel and is the technique used by solar panel 'farms' in places like Spain. It's most useful if you tend to sail in a constant latitude, since the optimum tilt angle is latitude-dependent.

If you choose to do this, consider whether to fix the tilt at a summer or winter position: you may decide that there is little need for winter energy input (it's cloudy, you rarely use the boat, there's plenty of shore power available) and so you will set the angle for summer cruising. Alternatively, you could find you have so much power available in the summer that an extra bit of free power in the winter will make you go for the winter angle.

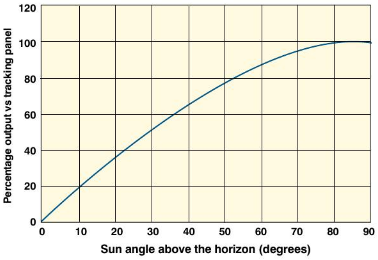
You can play with this interactive model and find the yearly optimum for yourself: http://pvcdrom.pveducation.org/SUNLIGHT/MODTILT.HTM.

Atmospheric path length vs hours after dawn



Light has to travel much further through the atmosphere when the sun is on the horizon. This is a purely geometrical effect; the actual energy lost will depend on the clarity of the atmosphere, but there is always some loss. (This graph assumes a 100km deep atmosphere and two-dimensional geometry.)

Horizontal panel output vs tracking panel



When the sun is directly overhead, a tracking panel and a horizontal panel will both provide the same energy. At all other points the tracking panel will have an advantage, as shown here. When the sun is at 10° above the horizon, for example, the horizontal panel will only convert about 20% of the energy available.

How much sunlight can you expect?

The final crucial piece of information you need to be able to scientifically specify your system is how much sunlight you can expect to receive. This might sound impossible, but in fact it's easier than you think, thanks to some handy scientific data published online.

In the PBO January 2015 article I had a look at the European Joint Research Centre's method of calculating insolation for chosen months and chosen locations worldwide. Their home page is here – https://ec.europa.eu/jrc – and is well worth a visit.

How can I find the maximum I am likely to get out of my panels?

Most people want to know this either to check their installation or to plan the size and number of panels to install. These days there are a number of web-based calculators available to help – one of these is provided by the European Commission Joint Research Centre (JRC) here: http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php.

I was interested in finding out how much my nominal 200W installation of crystalline panels should deliver in my chosen cruising area of Corfu in the summer months and then seeing if I could work back to estimate the efficiency of the installation taking into account the panels, regulator, wiring and general losses – in other words, 'from sunshine to battery'. The first thing I did on the webpage was choose the location, so using the map, zoom controls and mouse I navigated into the middle of the Corfu channel. I chose a sea area because the system has data on horizons and if I had selected, say, Gouvia Marina it would have shut off the virtual sun as it sank below the virtual mountains.

Next I selected the Daily Radiation tab and filled in some data. The database is the best around, so I left it at SAF PVGIS: this is where all the accumulated data for recent years is stored. I wanted data for August and also wanted average and clear sky insolation (irradiation), so I clicked those boxes. 'Average' takes account of any cloudy days using the accumulated data. Clear sky is blue sky every day from dawn to dusk. I also wanted to compare horizontally-mounted and fixed panels with those on a tilting mount, so I entered zero degrees for inclination to produce horizontal panel results. On a boat, azimuth is difficult to control, so I let orientation stay at zero; due south, but I selected two-axis tracking to produce a maximum for comparison.

I selected graphical output and asked for a pdf file so that I could keep the results, then hit 'Calculate' – and this is what I got:

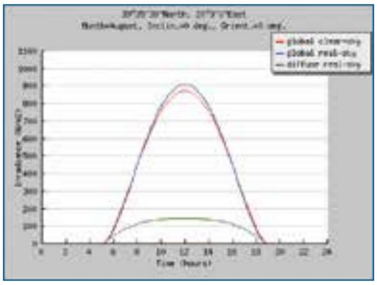


Figure 1 – Insolation on a horizontal panel in Corfu in August (European Commission JRC)

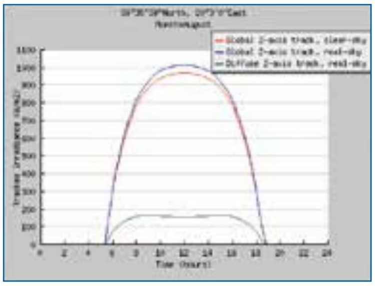


Figure 2 – Insolation on a two-axis tracking panel in Corfu in August (European Commission JRC)

The first obvious difference between horizontal and tracking installations is that the peak power output is less if you can't tilt the panel. This is because the sun is never exactly overhead in Corfu so they can't be equal. Secondly, the shapes of the curves are different, with the tracking installation being much fatter. This is the result of being able to capture energy when the sun is low: try comparing the values at the edges of the curves, say 7am.

Compare theory with reality

I wanted to extract something measurable from this result. One obvious thing would be electrical power. If I could measure voltage and current delivered to the battery at the same point and

Sarah Norbury

These semi-flexible solar panels have been cleverly incorporated into a sprayhood roof

time then multiply the two I would get power. So this would be something I could use my multimeter to check. I was aware from the start that there would be a number of assumptions and guesses in this calculation, some made by JRC (they explain these in their help sections) and some by me. Nevertheless, I should be able to get into the right ballpark. If I calculated the theoretical power then took my highest-ever measured current and voltage readings for August, dividing one by the other would give me the efficiency value I wanted.

I have a tilting mount so I could use the tracking results. My panels are a nominal 200W, which means if they are insolated at 1,000W/m^2 they would output 200W of electrical power at their maximum power point. The peak value of the tracking curve was 1,010 W/m^2 (from the tabulated results) so the peak output was: 200W * 1,010W/m^2 /1,000W/m^2 = 202W. The result for a horizontal panel returns 181W.

Unfortunately for my master plan, catching the greatest current going into the batteries is like trying to photograph a dolphin; by the time you've seen it, it's gone. The current depends on the load more than the source, so maximum currents are likely to occur when the battery charge is low, and that means in the morning – but the sun is not at its peak then. The best I've seen to date is 13.1A at 13.4V, giving me 170W and an overall system performance of 170/200 * 100% = 85%, which represents a system loss of 15%. In other words, 85% of the theoretical electrical output from the panel reaches my battery, which is pretty good.

Energy

The total area under the curve represents the energy collected in a typical day, and I wanted to quantify the difference between a fixed horizontal panel and a tilting one. This was fairly simple. I went to the PV estimation tab and filled in the blanks leaving the JRC estimate of system losses at 14% and entering my 0.2 kW solar panels. I entered zero for the angle to generate a horizontal panel output and also selected two-axis tracking since this was the comparison I wanted to make. The result is pretty graphic: you gain a minimum of 33% more energy if you can follow the sun; much more in winter.

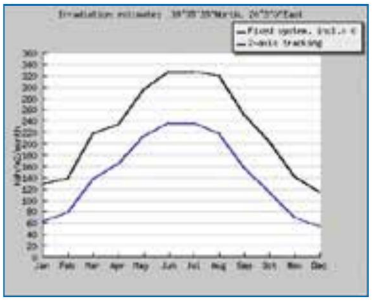


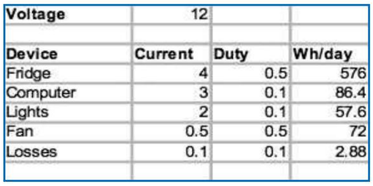
Figure 3 – Irradiation estimates by month for a horizontal panel and a two-axis tracking panel (European Commission JRC)

en.wikipedia.org

Two-axis tracking mounts allow solar panels to make the most of the available sun

Will your installation keep the batteries charged?

One last useful tab on the JRC website is the Stand Alone PV one. This assumes a system that is the type we have on board, where a set of panels feeds into a battery bank. The input parameters are obvious, with the exception of the Daily Consumption one. Here you have to do some assessment of your personal energy usage. Mine is like this:



Voltage	12		
Device	**Current**	**Duty**	**Wh/day**
Fridge	4	0.5	576
Computer	3	0.1	86.4
Lights	2	0.1	57.6
Fan	0.5	0.5	72
Losses	0.1	0.1	2.88

Figure 4 – Energy use per day. Current in amps, duty is a proportion of 24 hours

I determined the current of each major device (usually given on a placard somewhere) then estimated the maximum duty cycle, which is the amount of time the device is actually running. Multiplying current by the battery voltage gives watts, then multiplying by 24 hours and the duty cycle gives the daily energy use for each device in watt-hours/day. I added together all the values and fed the result into the box on the website. For me this came to 800W/day, so would my 200W panels keep up?

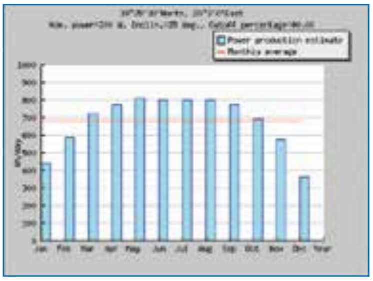
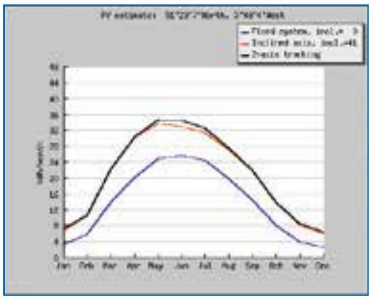


Figure 5 – Power produced from my 200W tracking array compared to my 800Wh/day requirement (European Commission JRC)

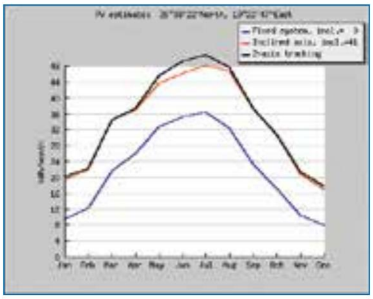
The blue bars show the energy produced, and these reach the target value of 800Wh/day throughout the cruising months of the summer. But the panels will need a bit of help from September onwards and before May.

But what about closer to home?

For comparison's sake I re-ran the model for the latitudes of Cardiff and Preveza, the two places in the world where I spend most time, and ran the model for all forms of mount. This is the result: whichever form of tracking is used, the result is always much better than for a fixed panel and, as I've shown above, an angled fixed panel is much better than a horizontal one. I encourage you to play with the models, plugging in your own values for your installation: the results can be quite illuminating (or should that be insolating?).



Cardiff annual energy for flat panel (blue), tilted but fixed (red) and fully tracking (black)...



...and the same for Preveza

VERDICT

If you're choosing solar panels, start by working out what space you have available and what your energy requirements are. Then try to find an unshaded location where you can mount rigid crystalline panels, preferably on a tilting mount. Many boat owners will want to mount them on deck, in which case semi-flexible crystalline panels may seem a sensible choice but can be up to 10 times as expensive as rigid panels. For tracking mounts or gantries, rigid panels will be necessary, so crystalline units will again be the best option.

Amorphous panels simply don't make sense any more, being much more expensive for much poorer performance.

ABOUT THE AUTHOR

■ **David Berry was a systems design engineer. He and wife Ann now cruise the Ionion in their Moody Eclipse. Their book *Time To Go South* is available on Kindle.** PBO

Fitting a wind turbine

Cut engine use – generate with wind power

Fitting a wind generator is a straightforward project. Mike Coates shows how he reduced the engine hours on his Hans Christian 43T with a Rutland 913 generator

In our windy northern European waters, a wind turbine is a practical way to generate a significant amount of extra power for your boat, reducing the amount of time spent with the engine on just to charge batteries.

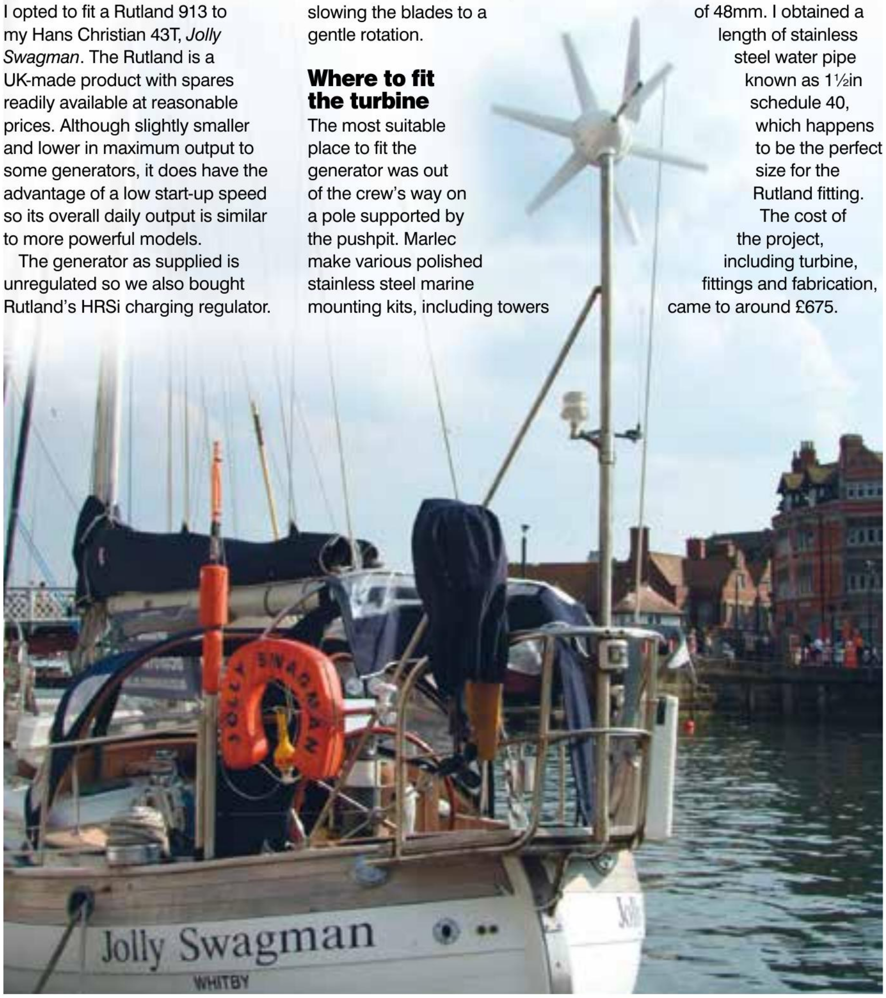
Having researched the specification of various generators I opted to fit a Rutland 913 to my Hans Christian 43T, *Jolly Swagman*. The Rutland is a UK-made product with spares readily available at reasonable prices. Although slightly smaller and lower in maximum output to some generators, it does have the advantage of a low start-up speed so its overall daily output is similar to more powerful models.

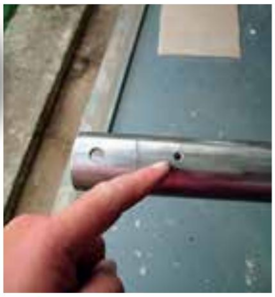
The generator as supplied is unregulated so we also bought Rutland's HRSi charging regulator. This is a pulse width modulation regulator: as the charge in the battery rises, the regulator places a pulsed short circuit across the generator output which has the effect of slowing its rotation and therefore reducing or stopping the rate of charge. The regulator also has a 'stop' switch that places a short across the generator, slowing the blades to a gentle rotation.

Where to fit the turbine

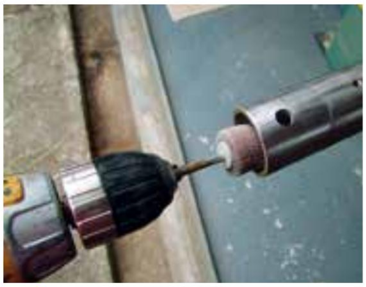
The most suitable place to fit the generator was out of the crew's way on a pole supported by the pushpit. Marlec make various polished stainless steel marine mounting kits, including towers and stays together with the necessary fittings, but as *Jolly Swagman* has a robust pushpit manufactured from 35mm stainless tubing I reckoned it would make a good structure to support the generator pole. The 913 is designed to mount into 41mm internal bore pipe with a maximum outside diameter of 48mm. I obtained a length of stainless steel water pipe known as 1½in schedule 40, which happens to be the perfect size for the Rutland fitting.

The cost of the project, including turbine, fittings and fabrication, came to around £675.

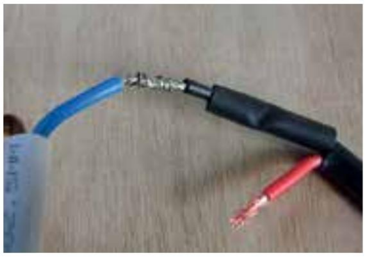




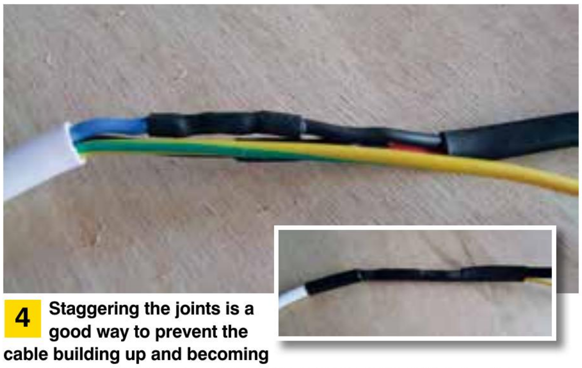
1 **First, I drilled two 11mm holes 20mm from the top of the tube to take the two retaining studs for the Rutland fitting, followed by a 5.5mm hole 80mm from the top to take the nut and bolt for the cable support.**



2 **The drilling left burrs inside the tube, so I cleaned them off with a flapper disc in a drill. This also removed the slight joint ridge from the tube manufacture, so that the mounting spigot on the generator could slide easily into the tube without damaging its anodising.**



3 **As I'll be spending extended periods blue-water cruising, I chose to solder the joints rather than use the screw connector block supplied. This will help prevent oxidation, which is important as I used heat-resistant immersion heater cable to meet the requirement for a connecting cable with a conductor of at least 2.5mm^2. This has plain copper cores rather than the expensive tinned conductors of marine cable. I prepared the wires and slid glue-lined heat-shrink sleeves onto the cable before soldering the joints.**



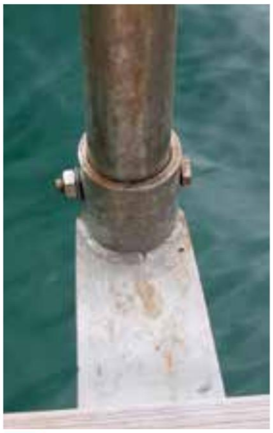
4 Staggering the joints is a good way to prevent the cable building up and becoming too thick at a single point. I insulated each soldered joint with a heat-shrink sleeve, then covered the entire join area with another heat-shrink sleeve (inset).

5 The earth wire from the cable is not needed for the wind generator, so I brought it out of the heat-shrink tube, supported it with more heat-shrink and soldered an eye to the end so that it can be used to hold the weight of the cable in the stainless pole.

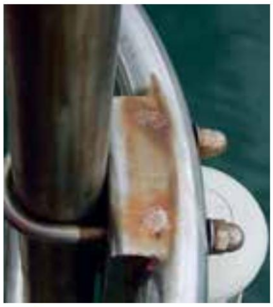
6 My next task was to assemble the hub. The six blades are pushed into position, and a rounded protrusion on each blade engages into a slot in the hub to prevent it being shed at high revolutions. Four self-tapping screws – two from the front of the hub and two from the rear – hold the blades in place.

7 Three nylon pan-headed machine screws are then used to attach the nose fairing.

8 It was now time to fit the generator to the pole, so I fed the cable down the pole and bolted the earth wire acting as the cable support to the pole with a 5mm machine screw. I had to first fix the nut and washer to a spanner with masking tape as the fixing was just out of reach down the tube. I then applied a liberal coating of chromate paste to the aluminium mounting spigot to help prevent corrosion between it and the stainless steel mounting pole, and used two 10mm button-headed Allen screws to fix it in place.



9 The pole needed a lower support bracket, which I made from a short section of thick-walled stainless steel tube that was a sliding fit over the pole. This was welded to a plate which I bolted through the lower crossmembers of the pushpit base. A single through-bolt retains the pole in the socket.



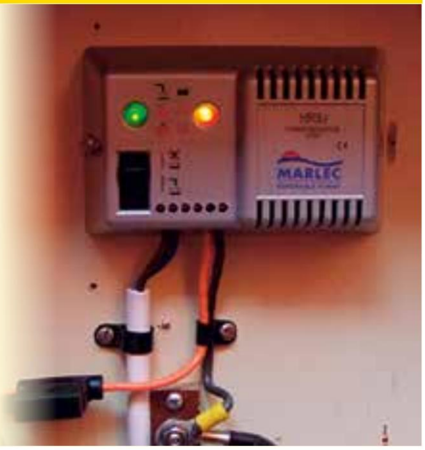
10 For the upper support I drilled two holes through the upper pushpit rail and the mounting bracket for the stern light to take a U-bolt that fits snugly round the pole. For a neat finish I used dome-headed nuts.

11 Despite the robust construction of the pushpit, I later found that in heavy weather the inertia of the 10.5kg (23lb) generator mounted high up out of harm's way was sufficient to cause the pushpit to twist alarmingly. To prevent this I added a pair of forward-facing bracing stays bolted firmly to the cap rail, and this has solved the problem.

12 The final stage of the outside installation was to feed the cable from the bottom of the pole through a waterproof gland into the aft locker. I used cable ties to fix it to the pushpit support, leaving a drip loop.

MOUNTING THE REGULATOR

I mounted the regulator in a dry ventilated locker as near as possible to the batteries, and once again soldered the cable ends to prevent oxidation. A fuse holder with a 20A fuse (provided with generator) is fitted between the regulator and the batteries, which I wired with 6mm² cable to minimise losses. The regulator's left hand LED indicator (showing green in the photo) indicates the generator is charging. When the LED is not lit it indicates that the generator is turning too slowly to commence charging, and when showing red it indicates the regulator is working hard to reduce the charge rate and cause the blades to spin slowly. The LED on the right showing amber is indicating the battery voltage is between 12V and 13V. If it shows green the battery voltage is higher than 13V, and when red the battery voltage is less than 12V.



Battery maintenance

Caring for your batteries will prolong their life and keep them in tip-top condition for when you need them most, says David Pugh

There are many battery technologies on the market: flooded (wet) batteries, absorbed glass mat (AGM), gel batteries and, more recently, lithium-ion. All have pros and cons, but the flooded battery is still the most commonly found on boats owing to ready availability and comparatively low price.

In flooded batteries, the electrolyte is a solution of sulphuric acid and water, surrounding lead plates. The problem is that if they are tipped over, this highly corrosive solution can spill out. In gel and AGM batteries, the electrolyte is suspended in a gel or glassfibre mat, making them tolerant to being mounted at a range of angles.

Keep an eye on them

Batteries of either type will give good service, but only if properly looked after. The first step to looking after them is to make regular visual inspections: check the casing for cracks and ensure terminals and connections are clean. By doing so you will be able to immediately spot any telltale spillages.

If you clean the terminals, give them a smear of Vaseline to prevent further corrosion.

Battery checks

There are two ways to check the electrical health of your battery. The easiest is to check the voltage, but for wet cells it's worth testing the specific gravity of the electrolyte using a hydrometer. Both tests should be carried out with the battery fully charged.

Voltage

You can use a basic DC voltmeter for this, but for an accurate reading the battery must have been idle for at least six hours.

Compare your voltage reading with the table. If it registers 70% charged or less, the battery is faulty. It may have been left discharged for too long, or may have a bad or weak cell.

Specific gravity (flooded batteries)

Remove the cap of the first cell, and rinse the hydrometer in distilled water a few times before taking a sample. There should be enough sample electrolyte in the hydrometer to completely support the float.

Take a reading, record it and return the electrolyte back to the cell. Then check the other cells. Correct them for temperature by adding or subtracting 0.004 to readings for every 10°F (5.6°C)° above or below 80°F (26.7°C), and compare them to the values in the table. They should all read at or above 1.277 +/- 0.007 for a fully charged battery.

Adding water

When you check the specific gravity is a good time to check electrolyte levels. If one or more of the cells is low, top it up using distilled or deionised water – never top up a cell with more acid. Try to only top up cells when the battery is charged, as electrolyte levels rise with charging, but if the level is below the top of the lead plates you should make sure they are just covered. When charged, the electrolyte level should be about 3mm below the bottom of the filling well. Too low a level can expose the plates and allow them to corrode: too high a level will spill acid when the battery is charged.

Battery storage

Batteries like to be used, which is bad news for boat owners as most of us lay up our boats for several months a year. However, with a few simple precautions you can keep your batteries in good condition over the winter months.

Always store your batteries fully charged. They keep better that way, and it also helps prevent them from freezing. That said, make sure that your batteries are not stored anywhere where they might freeze as it will cause severe damage to the battery's plates.

Keep an eye on the charge level, either by using a voltage test or by measuring the specific gravity. If it approaches 70%, you should recharge the battery.

Chargers

Multi-stage chargers are now commonly available and relatively inexpensive, and are a worthwhile investment as they charge batteries more efficiently and hence prolong their life. Most use a three-stage process, with a high-voltage, high-current bulk charge, an absorption stage which still maintains a relatively high voltage (typically around 14.5V) but takes the current down to a low level, and a float charge which uses a lower voltage (typically 13.2V) and very low current – 0.2A or so.

Battery charge vs voltage and specific gravity

Percentage of charge	Specific gravity corrected to 80°F (26.7°C)	Open-circuit voltage
100	1.277	12.73
90	1.258	12.62
80	1.238	12.5
70	1.217	12.37
60	1.195	12.24
50	1.172	12.1
40	1.148	11.96
30	1.124	11.81
20	1.098	11.66
10	1.073	11.51

When choosing a charger, first look at the capacity of your battery in amp-hours (Ah). The maximum charge rate (in amps) should be between 10% and 13% of this value, although less powerful chargers will get there eventually.

Some chargers offer an equalisation charge. This is a high-voltage charge designed to ensure that charge is evenly distributed across the battery plates and to help reduce the build-up of sulphates. This type of charge is only suitable for flooded batteries as it causes the electrolyte to bubble and significant hydrogen gas to be given off, for which reason it should only be done in a well-ventilated area. While the charge is taking place you should take specific gravity readings every hour – the charge is complete when the reading ceases to rise.

Discharging

Finally, as well as keeping an eye on your battery voltage and fluid levels, keep an eye on your usage. Flooded cells will survive a maximum discharge of 80%, but you will get much longer life if you never exceed 50% discharge. An occasional equalisation charge will help keep your batteries as fully charged as possible. Never leave a battery discharged for any significant length of time.

Fit a digital alternator regulator

Step by step guide

STERLING POWER PRODUCTS
GREEN: HIGH CHARGE RATE ON
YELLOW: TIMER ACTIVATED
GREEN: FLOAT MODE
ORANGE: LOW VOLTAGE WARNING
12 VOLTS
24 VOLTS
BATTERY TYPE: GREEN: GEL/SEALED
YELLOW: OPEN LEAD ACID
RED: A.G.M.
UNIVERSAL ADVANCED DIGITAL
4 STEP ALTERNATOR REGULATOR
BATTERY TYPE PROGRAM SELECTOR SWITCH, INSIDE LID
3 BATTERY TYPE POSITIONS
GEL SEALED L.E.D. (GREEN)
LEAD OPEN L.E.D. (YELLOW)
A.G.M L.E.D. (RED)
CE

PBO reader David Berry explains how he installed a digital alternator regulator to the engine of his Moody Eclipse 33, *Aderyn Glas*

When we travelled down through the canals of France to the Mediterranean we asked the people we met what they considered essential to support a life afloat in a climate so different to Britain. The answers generally fell into two categories: staying cool and power management.

To help with power management we fitted solar panels with 200W of output that can deliver a staggering 10A on a sunny day. Along with the solar panels, another way of maintaining maximum charge in our batteries was an advanced alternator regulator.

Choice of regulator for us boiled down to either Adverc or Sterling, with the Sterling unit marginally cheaper. Sterling reckoned their Digital Advanced Regulator (DAR) was the most cost-effective solution for simple alternator installations, and as our 1992 Volvo-Penta 2003T falls into that category we bought one. In the box is the unit itself and a set of instructions.

The DAR is designed to control the charging power fed into the battery bank from the alternator. Instead of relying on the default proportional power curve that the inbuilt alternator regulator provides, the DAR is microprocessor-controlled to provide boost power and float maintenance power outputs that will ensure the quickest and fullest charge.

These units have one drawback: they require connection to the brushes inside the alternator itself, and many people are put off by the thought of taking the alternator apart. On our standard-fit 50A Valeo alternator it's not too difficult, but you do have to be able to solder. Be sure to disconnect the power from the alternator before disconnecting its wires (turn the 1-2-Both switch to 'off', for example).

Installation help

The instructions that came with the unit were adequate, and Charles Sterling also provided rapid support to my queries by email or phone.

The best thing about the instructions is that they walk you through the installation in a logical, step-by-step manner requiring you to learn necessary facts about your alternator and leading you to the final setup for your installation. They help you determine whether you have a positive or negative ground system, and which of the wires from the brushes is the one to connect to the device.

One point the instructions make clear is that the output power from your alternator will be far greater than before, and you need to ensure that the rest of your system – the cables, switches, terminals, connectors, the alternator drive belt and the batteries themselves – are up to it. You will also have to get used to topping up the batteries with water more often.

They also tell you which DAR wire goes where, but there are some alternatives that are worth mentioning – my thanks go to Charles Sterling for suggesting some of these solutions and taking the time to explain a few of the finer points. In summary:

The red sense wire needs to know the voltage at the battery you want to charge. That's fine in theory, and if you only have one battery it's fine in practice – just connect it to the positive terminal of the battery and you're done. But most of us have a number of batteries grouped into domestic and engine start banks, so where do we put the sense wire? The answer is as near the common point of the battery banks as possible. In my installation this is the 1-2-Both switch – I just have to connect the red wire to the 'common' post of the switch and the DAR will sense the voltage there which should be pretty close to the voltage of the battery I'm charging.

Unfortunately, in my case Moody built the switch first and the boat around it and I can't get to the common post at the back of the switch, so I followed the largest diameter wire from the common post until I found a place where I could get the sense wire onto it. This was back at the engine, at the starter solenoid.

Sensing the voltage there is not perfect, but not too bad either – the wire from the switch is so large that the voltage drop will be small and, again, as the charging current drops so does the voltage difference.

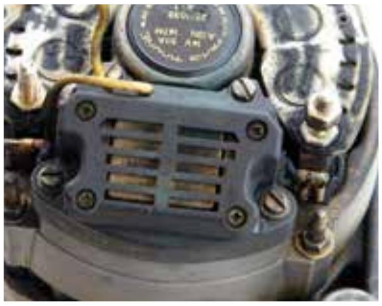
The unit comes with a temperature sensor which you can fit to a battery terminal. It will measure the temperature of that battery terminal and adjust the charging cycle to suit. Here, of course, is the next problem. If you fit the sensor to battery 'A' and charge battery 'B' then the unit may overheat 'B' because it has no information about its temperature.

Sterling suggest ignoring the temperature sensor in all but the simplest cases and relying on the unit to sense the ambient temperature wherever it is mounted. While this isn't going to be optimal it sounds sensible, so I left the sensor out of my installation.

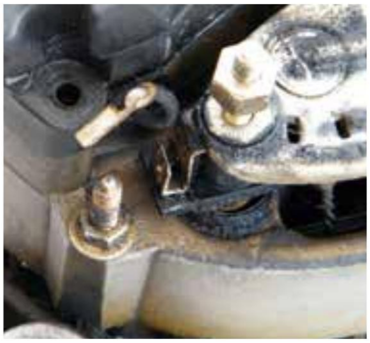
Wire colour	Connect to…
Brown	The D+ terminal on the back of the alternator.
Red	This is the voltage sense and should go to a point near the battery you want the DAR to charge. However, the choice is not so simple in the real world – see main text.
Black	The B- terminal on the alternator. There are two black wires in parallel: don't separate them, they're both needed.
Yellow	The instructions refer to this as a 'simple ignition feed', which doesn't mean much to me. However, you can either connect this to a feed on the engine which is live when the 'ignition switch' is on (there isn't a wire like this on the 2003T, which is live all the time), or you can connect it to the D+ terminal on the alternator.
White	Join to the selected wire from the alternator brushes.

WIRING INTO THE ALTERNATOR

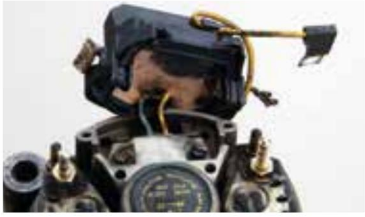
1 With my original-fit Valeo Paris-Rhône 50A alternator, the first thing to do is to disconnect the yellow wire from the terminal post and spade connector, but leave it attached to the built-in regulator housing. Then, with a wide tool such as a flat screwdriver, carefully lever the main plastic cover off the rear of the alternator: it's a clip fit – there are no screws holding it.



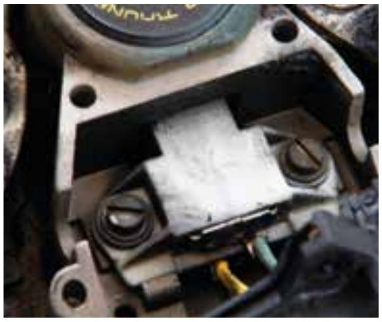
2 You now have access to the four slotted-head screws that hold the regulator (the black plastic assembly) in place. This is probably a good time to clean up a bit with some meths. Remove the screws, but do not remove the regulator yet.



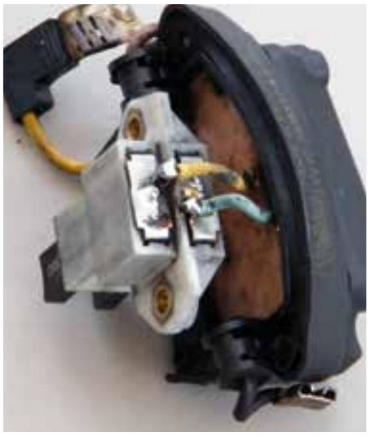
3 Disconnect the spade connectors on each side of the regulator by gently easing them upwards with a small screwdriver.



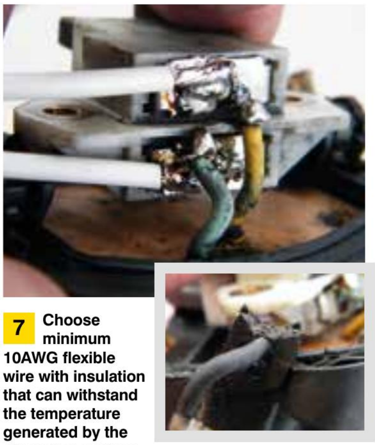
4 The regulator may be reluctant to come free, in which case you have to be firm but careful. There are no other screws holding it, so just keep working around it with a suitable tool until it moves. In this shot you can see the two wires running from the white plastic brush holder into the potting beneath the regulator. This is the fragile bit: if you break these wires you will have to buy a new assembly, so don't wriggle it around too much!



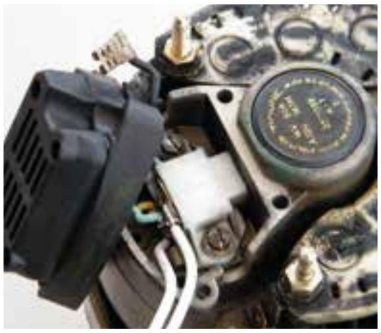
5 Remove the two slotted screws that secure the white plastic brush holder, lift the end where the wires are attached and slip it out backwards and upwards.



6 This is the assembly you have to attach wires to. The brushes and the regulator wires are soldered to the tags at the top of the holder and you have to attach two more wires, one to each tag, and lead them to the outside world. It's a good time to clean the unit of any carbon dust with a small brush and some meths (not white spirit, since that leaves a residue).



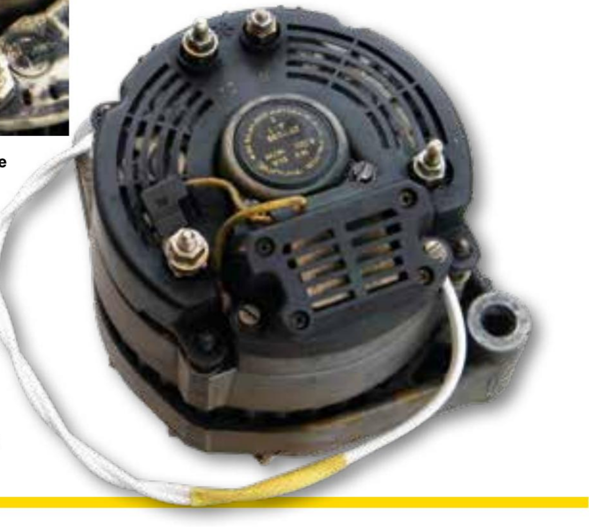
7 Choose minimum 10AWG flexible wire with insulation that can withstand the temperature generated by the alternator, and use a hot iron. Tin the wire and tin the tag because you want to make the joint quickly to avoid melting the existing soldered joints. I'm not sure if the brush will fall out if you melt its connection, so it's wise to hold it while you solder. The best route out for the new wires is through one of the moulded seals at the side of the regulator housing. Choose the seal that has only one existing wire and carve the rubber away very carefully with a scalpel – remember, the existing moulded-in wire must not be cut or bared.



8 That's the hard bit done! Replace the brush holder and lead the wires to the modified seal.

9 Reassemble everything, remembering to remake the spade connections from the alternator's regulator and to reconnect the yellow cable.

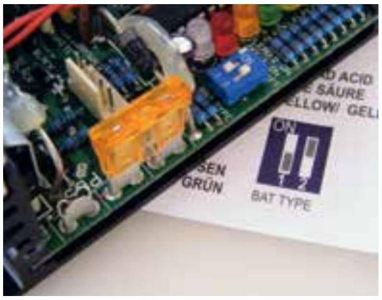
Seal the space around the exit of the new wires with a squirt of something that can take the engine room temperature. Temporarily insulate the cut ends of the new wires to prevent them touching anything, including each other. That's it – the alternator has been modified and you can bolt it back onto the engine.



INSTALLING THE REGULATOR

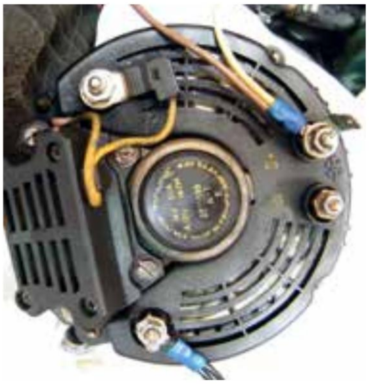
STERLING POWER PRODUCTS
UNIVERSAL ADVANCED DIGITAL
4 STEP ALTERNATOR REGULATOR
CE

1 The DAR is built on a circuit board enclosed in a case. Undoing four screws gets you access to the things you have to select – the ground arrangement (positive or negative) and the battery type. The circuit is carried on a heat sink: Sterling report that it will happily run at 90°C, so mounting it in the engine compartment in my Moody in the Med is not a worry.

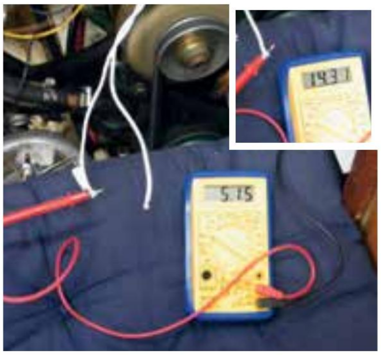


2 The orange fuse is positioned to select between positive and negative grounds, and the instructions will tell you how to determine which you have. The blue DIL switches are there for you to select your battery type – mine is 'open lead acid' and the picture shows the setting for that type. Others are 'gel sealed' and 'glass mat' types. The setting determines the charge profile the unit will follow.

3 Because I couldn't get to the back of the battery selector switch (inset photo) in my Moody I attached the red voltage sense wire to the fat supply at the starter motor. The sense wire is the thinner of the two red wires. This is acceptable since the voltage loss in the large supply cable is minimal during charging. However, don't take this easy way out if you can do better. Get the end of the sense wire as close as you can to the batteries you want to charge.



4 Because the Volvo 2003 is a little tight to work on I decided to make the DAR wire connections to the alternator before replacing it on the engine. Here you can see the twin black wires on the B- terminal, and the yellow and brown wires on the D+ terminal. The yellow wire is the 'ignition feed' and is normally taken to the 'ignition switch' – a supply that is switched on before the engine can run. Since the Volvo electrics are live all the time this option was not available to me, so I took the alternative and connected the yellow wire to the D+ terminal along with the brown.



5 With the engine running, measure the voltage from one of the new (white) brush wires to ground. Make sure you mark the two wires so you can identify them afterwards. Of the two wires, the one with a voltage reading between the 2V and 10V predicted by the instructions is the one I'm after. The other wire (inset photo) measured 14.31V and is the one I therefore don't need. After the test I cut this one back and sealed it with heatshrink sleeving to prevent it from making contact with anything.

It's worthwhile measuring the output from the alternator at the same time, just to be sure your alternator is up to scratch.

POWER PRODUCT
RGE RATE ON
ER ACTIVATED
FLOAT MODE
GE WARNING
LTAGE TRIP
ERY TEMP
HIGH ALT V
GEL/SEALED
N LEAD ACID

6 The white wire can be switched – I used a crimp bullet connector – which allows you to disconnect the unit for whatever reason. One good reason is to see the difference in charging voltage when the unit is working. If everything works, you should get a pretty light show when the engine runs.

Has it worked in practice?

Did we benefit from fitting a digital alternator regulator? Ironically, maybe not for our Med cruising. We fitted the unit in France before sailing to Greece and expected there to be a constant supply of wind as we sailed south, but in fact the wind was either too much or too little: hands up those who've heard this before? This meant we motored much more than we anticipated and the batteries would have been fully charged by the normal alternator-regulator combination. We also have those lovely solar panels which provide lots of amps while we rest in the heat of the day, of course.

ADERYN GLAS

David Berry sails his Moody Eclipse 33 *Aderyn Glas* in the Ionian

Upgrading electronics

Thinking of replacing your boat's instruments? Read this before you start searching...

▲ **Raymarine's eSeries MFDs form part of their range of plotters**

Until recently, instruments were something you replaced as units. If the echo sounder or log went wrong and you couldn't fix it you would buy a complete replacement, including the transducer. There was no guarantee that the new unit would fit in the space left by the old, with the result that many boats can be found with botched plywood panels covering holes made by past electronics. But as time went on, manufacturers started to standardise on 4in-square instrument heads, allowing some degree of uniformity, and the early NMEA standards began to allow instruments to share data.

The major brands then started to offer fully integrated systems using higher-speed networks, but would only connect to instruments from their own ranges.

All change

One of the reasons for tying customers into a brand was that the existing communication protocol, NMEA 0183, was just too slow to keep up with items such as wind transducers or gyrocompasses. Any delay on this type of data can make it much less useful, especially for autopilots. The US-based National Marine Electronics Association responsible for NMEA 0183 was working towards the new, much faster NMEA 2000 standard, but they weren't going fast enough for the industry: so the instrument manufacturers took early versions of NMEA 2000 and developed them into in-house systems for their own products.

Of course, locking customers into a single brand is also good for business, so once NMEA 2000 was complete it took a long time for it to be fully accepted. Apart from a few specialist brands, Lowrance were the first major manufacturer to embrace NMEA 2000, followed by Garmin when they entered the instrument market in 2008. With two major manufacturers signed up, others were sure to follow.

Raymarine and Simrad now support the protocol as well as their own Seatalk and Simnet versions, while the new B&G Triton instruments exclusively use NMEA 2000. In fact, some differences now seem to be purely hardware – for example, a Simnet to NMEA 2000 converter is simply a cable with a Simnet connector on one end and an NMEA 2000-standard Micro-C connector on the other.

In addition to electronic protocols, instruments seem to have been becoming physically more interchangeable. The 4in display head is standard, and most manufacturers have adopted a 3.5in circular cutout for the bulkhead behind. This is probably to ease installation for boatbuilders – who would rather make one hole with a holesaw than cut irregular shapes – but it has also eased installation for DIY upgrades and hopefully means that subsequent changes will be easier.

New technology

The centre of a modern boat's electronics is the chart plotter. Data from GPS, wind, depth and speed transducers and other data sources are shared on the boat's network, and the plotter provides a master screen on which to view them. Once you have a plotter, you can see all the data you need on a single screen – the simplest new installation would probably be the transducers you need, networked to a plotter in the cockpit.

You can see this in the way manufacturers now refer to their plotter and instrument displays. Most will now sell you an MFD – multifunction display – rather than a wind or speed display. That's the concept of a modern installation: every piece of electronics has access to all the information from every device on the boat, and you simply choose what you want displayed where. Instruments are now simply

B&G
Raymarine
GARMIN
35.9

▲ Instruments from B&G (Triton), Raymarine (i70s) and Garmin (GMI20)

▲ Many modern plotters, including Simrad's NSS, have hybrid control systems enabling the use of a touch screen and pushbuttons

▲ B&G's Zeus2 range of MFDs can display laylines and sailing-specific information

Raymarine
B&G

▲ Raymarine's Dragonfly (left) and B&G's Vulcan (right) range of plotters are low-cost options

screens, so if you want to change what you see – say, show depth instead of wind data on the starboard instrument display – you can do it at the touch of a button.

So what's on the market?

In the UK, five major manufacturers provide complete systems including instruments, radar and chart plotters: B&G, Furuno, Garmin, Raymarine and Simrad. NASA and Tacktick specialise in instruments, while Lowrance offer plotters, sounders, VHF and several other items, with the exception of instrument heads.

Although branded separately, B&G, Simrad and Lowrance are all part of the same group (Navico) and share many items such as black box sounder units and radar scanners. Raymarine own Tacktick, but so far the instrument ranges have remained separate.

A spin-off of adopting NMEA 2000 is that many manufacturers are now using third-party transducers – odds are that whoever you buy your equipment from, you'll end up with Airmar depth and speed transducers. Most use proprietary wind sensors.

B&G

Although B&G (originally Brookes and Gatehouse) started out manufacturing instruments for all types of sailing, as time went on their speciality became electronics firmly targeted at racing.

Recently however, they have widened their niche again to provide for cruisers too, while retaining a focus on sail – all the other brands try to offer something for both sail and power. B&G started by introducing the Zeus plotter range, which has sailing-specific functions such as laylines and tack angles built into the software, and in late 2011 made a strong play for the cruising boat market by introducing their Triton range of instruments at a price

VHF radios

While a networked system is great for items that need a high-speed link, NMEA 0183 is plenty fast enough to provide GPS information to a DSC VHF radio, although for ease of installation the big manufacturers offer NMEA2000 VHFs as well. Nonetheless, you find many people opt for a different brand of VHF to their instruments.

Manufacturers include Icom and Standard Horizon. Both companies have their roots in commercial VHF and amateur radio, so are well worth considering when you upgrade. Standard Horizon offer a range of six fixed units and five handhelds, while Icom offer six and seven respectively. Both companies also sell AIS systems.

▲ The Icom IC-M505 is a popular choice of VHF similar to or even slightly cheaper than the competition. Last year they launched their Vulcan brand, which offers 'entry level' 5in and 7in plotters at a low price.

The new range works on an NMEA 2000 network, with the only variation being that B&G provide a loop-through connector on the back of the Triton instruments which allows you to 'daisy-chain' them. Strictly speaking, NMEA 2000 should have separate 'drops' to each instrument from a backbone cable, but B&G's modification can help with a neater installation.

The good news is that the new items are fully compatible with their race instruments, so if you want a Triton/Zeus/Vulcan system with a couple of mast displays, for example, you can. Zeus is compatible with the 4G broadband radar scanner common to all Navico brands, and the system can link to autopilots from either B&G or Simrad's range. They also offer ForwardScan, which is a forward-looking echo sounder.

FURUNO
34°
NXT
FU
NO

▲ **Furuno are well known for their radars and commercial vessel equipment, but have recently started offering a range of NMEA 2000 networked instruments for pleasure craft as well**

Simrad

Simrad offer a full range of gear to suit most tastes. Their button-driven NSE plotters share the same hardware as the B&G Zeus system, but with different software to suit a different market. They also offer NSS, similar to NSE but with a hybrid control system which allows you to use both pushbuttons and a touch screen. A black box plotter, NSO, is also available for larger installations.

Instruments are provided for with their well-established IS20 range and, more recently, the colour IS40 units. The IS20 range offers a choice of four dedicated analogue gauges, a combi display and a multifunctional graphical instrument, all with black and white screens. The IS40 units feature customisable colour screens.

Two sounder modules are available, while radar users can choose between Navico's broadband radar system or a conventional pulsed unit. There are also two AIS systems, two DSC VHF units, a complete range of autopilots to suit wheel or tiller steering, and even an entertainment system, SonicHub2, that allows you to control your music from the plotter.

Furuno

Furuno are probably best known for their radars and commercial vessel equipment, but have recently started offering a range of NMEA 2000 networked instruments for pleasure craft as well.

Their Navnet TZTouch range of plotters are touchscreen and use charts from their subsidiary MaxSea. Radars, including their new pulse-compression radome are also available, as are NAVpilot autopilots and AIS transponder and display units for leisure craft.

Garmin

Garmin bought sailing instruments specialist Nexus in 2012, and have recently launched new instruments which build on that know-how. That gives them a full range of chart plotters, instruments, AIS units, radars, autopilots, fishfinders and VHF radios. Garmin's flagship instrument head is the GMI20, which uses a colour screen to show any of the information on the network, including some nice graphics to give an analogue 'feel' where required. This same instrument is slightly modified to control the autopilot.

The sailing instruments are part of the GNX range, which offers low-power displays and wireless wind transducers as an option, alongside larger mast displays.

A wind sensor uses twin fins for directional control and a forward facing 'propeller' for speed.

Garmin have a large range of small plotters with 4in and 5in screens, all of which are button-driven. With screens from 6in to 12in you have a choice of buttons or a touch screen – Garmin do not offer a hybrid system – while the 15in models are touch screen only. There's also a large range of small fishfinders and echo sounders, some of which also display charts. Their latest plotters offer sailing features like laylines, as well as race start functionality.

Off-network instruments

Nasa Marine are almost unique in offering standalone instruments in the modern market, so are well worth a look if you're looking to upgrade piecemeal or on a budget. Their Clipper range offers speed, depth and wind, as well as some less common items such as a GPS repeater, battery monitor and digital compass.

For use below decks, the range extends to include AIS, Navtex, a recording barometer and WeatherMan, a device to download forecasts from the German national weather agency. Apart from AIS, these units require no interface with other equipment so work well independently of a network.

▼ **Nasa's range of stand-alone instruments includes their new wireless wind system**

CLIPPER
WIND
8.9
KTS

Raymarine/Tacktick

If Simrad's range is large, Raymarine's is gargantuan. At the time of writing, Raymarine offer a choice of five styles of instrument, three colour and two black and white. The more traditional ST60+ range also offers analogue displays.

This huge range is complemented by six styles of plotter, using either conventional button-driven interfaces or a hybrid system which allows control from buttons or via a touch screen. The choice of radar is almost as broad, with radomes and open array scanners in three types: digital, high definition and super-high definition, plus the recent addition of their new Quantum pulse-compression radar for small craft. There are also four VHFs, four sonar units and three AIS units.

One of the things for which Raymarine are best known is their autopilot range, and with good reason. In common with their other ranges there is a huge choice, making it possible to build a system to suit most boats, whatever their needs, size or steering arrangements.

Raymarine are part of US-based thermal camera company FLIR, so their range includes cameras for both day and night vision. They also offer satellite TV systems.

Raymarine also offer what was known as the Tacktick range, which take a quite different approach, with black-and-white screens and wireless transducers. It's a great way to reduce wiring or do a quick installation.

GARMIN
3:58
Stop
343°
340 BTW °M
22.1 DTW nm
HDG °M

▲ **Garmin have recently updated their offering to add sailing features, wireless wind and low-power displays**

Choosing new electronics

If you choose to install new electronics, you first need to decide whether you want to take advantage of networking. If not, standalone systems are still available – NASA Marine will sell you a log display and transducer, for example – and these can mostly be linked by the older NMEA 0183 standard. Tacktick offer multifunction displays which take advantage of data shared on their own wireless network, but limit their interoperability with other equipment to NMEA 0183.

If, on the other hand, you prefer the idea of a high-speed network, you will need to make a significant initial investment in NMEA 2000-compatible transducers and displays. The good news is that the communication standard looks set to remain so for some time – there's no hint of a replacement from the National Marine Electronics Association for NMEA 2000, and new standards take years to complete – so further upgrades to your kit over the next few years at least should be straightforward.

Think carefully about what you really need. The huge benefit of MFDs is that you can instantly change their purpose, so if you're happy to push buttons regularly, one display might be all you need. Mounting the plotter on deck is a good way to display extra data, so a simple installation might have a plotter in the cockpit and a single display used to show wind or depth information.

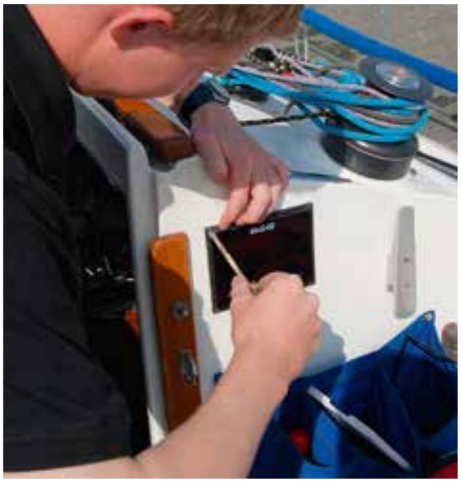
Also, don't feel obliged to stick with a manufacturer. You might wish to for aesthetic reasons, and many manufacturers will offer starter packs whose prices make it senseless to buy individual items, but if you prefer one brand overall but spot something you particularly want to include in your system from another, it should be possible. And don't forget that you can always add extra components later on – the true benefit of a network is that as soon as you plug in a new piece of equipment, all the network data is available to it, and vice versa.

DIGITAL YACHT
iAIS Wireless AIS Receiver

▶ **Most modern MFDs allow you to replicate their display on an iPad or Android tablet. You can also display any data on a NMEA2000 or 0183 network on your tablet via a Wi-Fi gateway such as Digital Yacht's iAIS**

6.23
WINDIR
064
TRUE
AWS KTS 23.8
9° HDG TRU
CH WIND 8.9
DTW NM 20.
SPEED 12. 13. DEPTH
096 096
330 330

▶ **Raymarine Wireless instruments (formerly Tacktick) offer wire-free installation**



Fitting new instruments

Ben Meakins sets about upgrading the instruments on *Polly*, his Impala 28, utilising NMEA 2000 'plug-and-play' connectivity for an easy installation and high-tech features

Instruments have never been more adaptable. On modern, bright colour displays with low power consumption you can display speed, wind, depth and navigation data to suit your heart's desires.

Over the winter, we decided to upgrade the instruments on *Polly*, our Impala 28. We wanted a small plotter in the cockpit, and while our old Tacktick instruments had done well, we wanted to upgrade while they were still serviceable. Not only would we gain some useful functionality and the ability to link in a cockpit chart plotter, but we could sell the old instruments as a working set and recoup some of the cost.

We wanted to move the instruments from the cockpit bulkhead to the hatch garage, which would make them more visible, and allow us to put a small 5in plotter in their place. All the major manufacturers have modern, bright displays with low power consumption, but based on previous experience, we chose to install some kit from B&G.

The shopping list comprised:

- **2 x Triton displays**
  These bright, highly visible displays can show any data on the network, and will be mainly used for depth, speed and wind – but can be customised to display navigation data as well.
- **1 x DST800 triducer**
  This single transducer would replace our separate speed and depth transducers.
- **1 x 508 wind sensor**
  This wind sensor would need a wire running down the mast to replace the old, wireless system.
- **1 x B&G Vulcan 5 plotter**
  This tiny plotter will give us digital charts in the cockpit, and will also act as another instrument display for extra data.
- **1 x B&G ZG100 GPS/ heading sensor**
  This GPS sensor (not strictly necessary as the plotter has an internal GPS) is also a compass heading sensor, which we wanted for wind shift information when racing and cruising in tidal waters.

But before installing the kit, we had some glassing and repair work to do...

Removing the old instruments

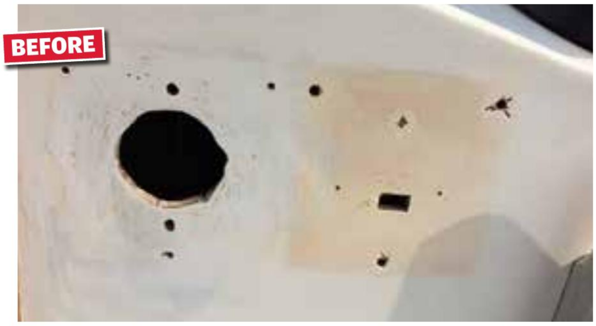
The old instruments unbolted from the bulkhead easily to reveal a bit of a mess. We decided to site the instruments on the hatch garage to make them more visible. The plotter would then go where the old instruments had been sited. However, its footprint was smaller than the old instruments, and the gelcoat had many holes and was badly discoloured in this area. We decided to re-gelcoat the area.

First, I masked up the area that we wanted to re-gelcoat before sanding it back harshly with an 80-grit disc in a random-orbit sander. We filled the redundant holes with epoxy and glass cloth in the same way as used to fill the old transducer hole (see page 47) so they were flush with the bulkhead.

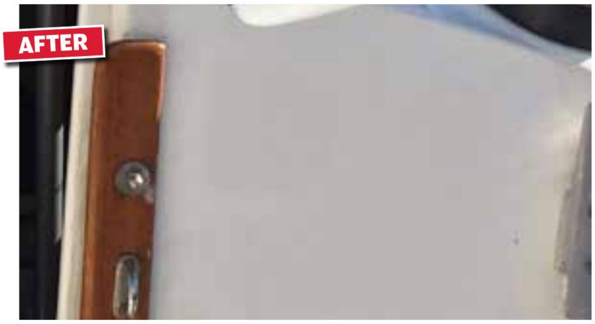
We then sanded back the repairs and area to be re-gelcoated. *Polly*'s gelcoat had a slightly yellow hue after 30 years, so we tinted some white gelcoat with a dab of cream from a Blue Gee Colormatch pigment pack (inset) which matched the colour well after some trial and error.

This done, I added catalyst to the mix and painted on the gelcoat with a brush. Once each coat became tacky, we applied another, up to four thin coats. For the final coat, I added 2% wax-in-styrene to allow the gelcoat to cure by excluding air. When cured, it could be sanded back with progressively finer grades of sandpaper. The end result looked much better – a blank canvas ready for the new 5in chart plotter.

COLORMATCH



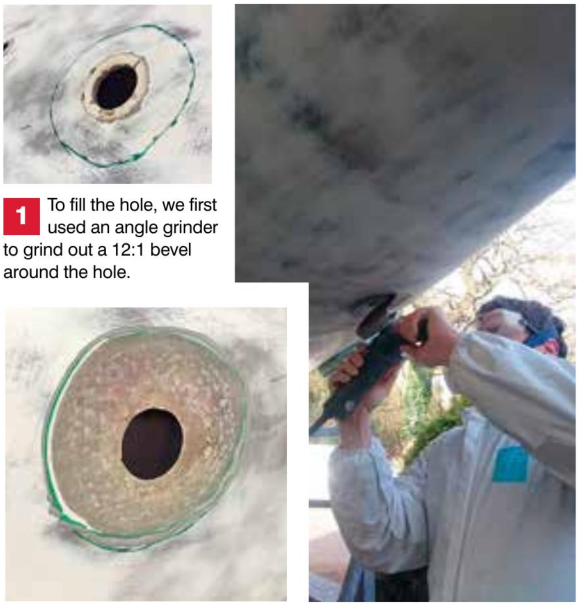
Holes and damage from a variety of old instruments needed filling



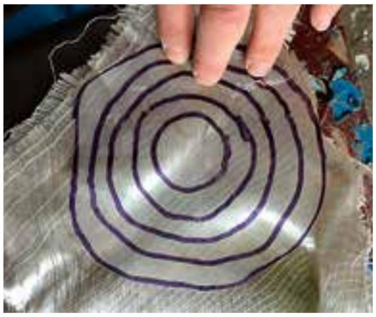
Filled, ground back and re-gelcoated, the bulkhead is ready for the plotter

Filling the transducer hole

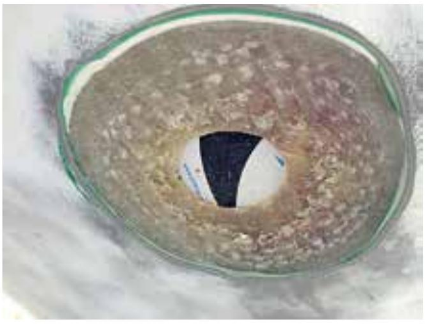
As the new system only required a single transducer, we could remove and fill one of the existing holes. The speed transducer was furthest offset from the centreline, so we removed that transducer.



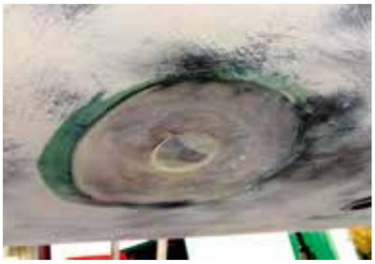
1 To fill the hole, we first used an angle grinder to grind out a 12:1 bevel around the hole.



2 Next, we used some transparent plastic sheet to draw the hole shape on. The hull was 8mm thick, so we needed eight layers of glassfibre to fill it. We drew seven concentric circles inside the larger one, which would give us sufficient thickness and shape to fill the hole.



3 We taped a flexible plastic pad inside the hole and weighed it down with a heavy bag of sand – this would give us a surface to press the repair against and mould the pad to the curve of the hull.



4 We painted a silica-rich mix of epoxy onto the bevel and hole and waited for this to become slightly tacky.

5 While waiting, we cut out our glassfibre discs. These were then wetted out with epoxy and placed together so they made a plug with progressively smaller layers.

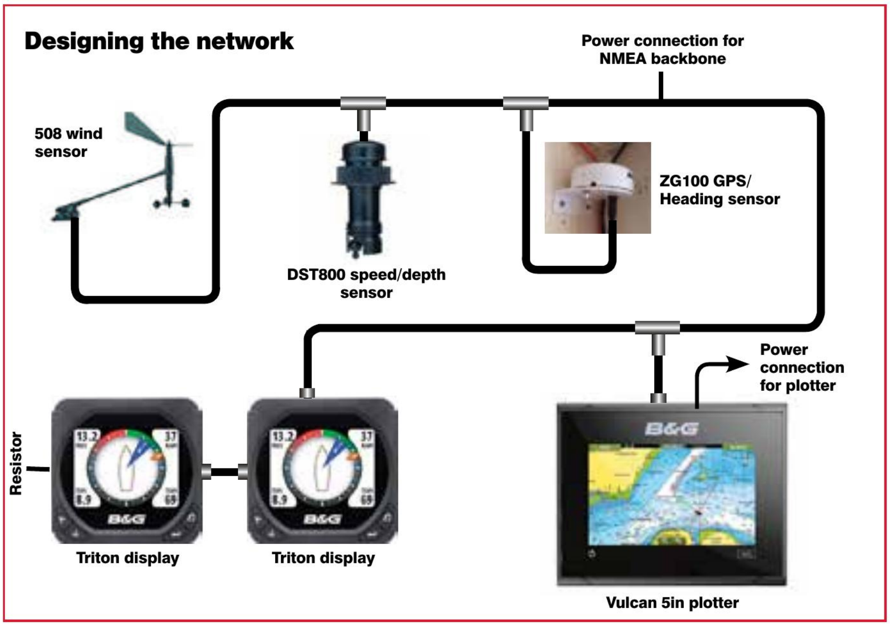
6 Once the epoxy was slightly tacky, we pressed this disc into place, largest disc first, and used a consolidating roller to remove any voids or air bubbles.

7 Finally, we taped a layer of peel ply over the repair. This tears off after the repair has cured, leaving behind a smooth, wax-free surface.

8 With the epoxy cured, we could sand back and fill with a fairing mix to fair the hull. We also added a layer inside the hull for extra strength and bonding.

NMEA 2000

You can buy 'stand-alone' instruments from NASA and others, but these days most are linked to a network to share data. Modern instruments use NMEA 2000, which refers to a standard to which they must comply. Unlike its predecessor NMEA 0183, NMEA 2000 really is 'plug and play': there's no fiddling with tiny wires, but threaded plugs are simply connected to a backbone. The backbone carries power and data to any devices on the network, which are connected via threaded T-piece connectors – think of a water main with feeds to individual houses and you won't go far wrong.

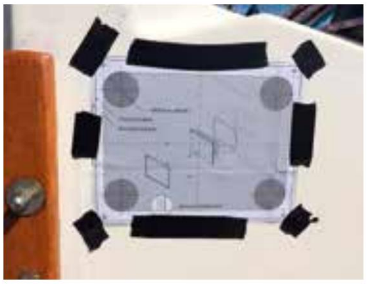

Designing the network
Power connection for NMEA backbone
508 wind sensor
ZG100 GPS/ Heading sensor
DST800 speed/depth sensor
Power connection for plotter
Resistor
Triton display
Triton display
Vulcan 5in plotter
B&G

Designing the network

We based most of our T-pieces in the forepeak: this was close to the speed transducer and was the intended location for the GPS/ Heading sensor, and the wiring for the masthead wind transducer could easily be run here, minimising the wiring. Each end of a NMEA 2000 network must have a resistor installed – and as the wind sensor has one integrated, it should be placed at one end of the network backbone.

From below the forepeak bunk it ran through the heads, where it was connected to power from the old instruments, and into the saloon, above the headlining. It headed to the starboard cockpit bulkhead, the location for the plotter, before running into the hatch garage, where we were to move the instruments – and here it terminated. The Triton displays have the ability to be 'daisy-chained', or connected together with short drop cables, obviating the need for extra drops from the backbone and extra wiring.

Fitting the plotter



1 The next job was to cut the hole for the plotter in our newly-repaired gelcoat. The Vulcan 5 came with a cutting template which, carefully cut out and stuck on the bulkhead, gave the dimensions. Be sure to align it properly at this point – there's no going back!

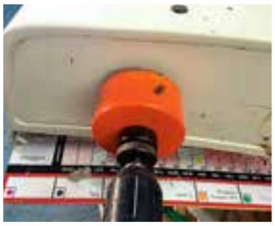
2 Next, each corner could be drilled with a 25mm flat bit in a drill to provide radiused corners.

3 The rest could then be cut out with a cordless jigsaw – useful, as the boat was on a mooring with no shore power available.

4 Tidied up with a file, the hole was ready for the plotter. We applied the sealing gasket before fitting the plotter to the hole and using machine screws to bolt it in for extra security. It's worth using a countersink bit on the mounting holes to avoid the gelcoat cracking.

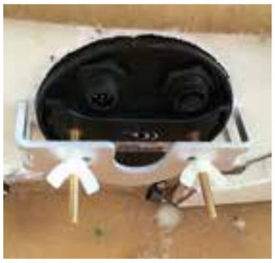
All fitted, wired up and working! I made a teak box to hide the wiring

Fitting the instruments

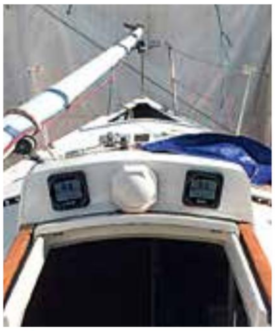


1 We'd decided to fit the instruments to the hatch garage – and with this off for repainting, I carried out this task in the garage at home. First, I cut a 89mm hole with a holesaw.

2 With the garage repainted and all wood edges sealed, I could fit the locking ring. This is secured with machine screws, and the instruments simply click in with a quarter-turn.



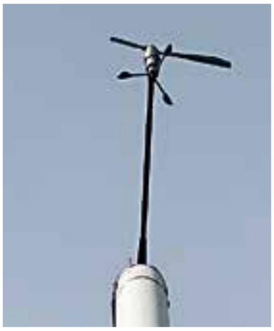
3 However, the instruments will be in a high-traffic area and vulnerable to knocks and theft, so I opted to fit the optional security bracket, which secures them from the back of the panel.



4 Fitted to the garage, wired up, and the hatch garage fitted back to the boat.

Running the mast cable

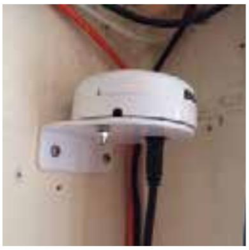
Our old instruments were wireless and thus needed no mast cable – but the new ones obviously did. To enable this, I sewed a mouse line to the tricolour cable and pulled it through, using this mouse line to then pull back the tricolour cable and the new wind cable as well. I greased both cables with silicone grease to aid their passage through the cable conduit in the mast – and it worked well, with both cables appearing easily.



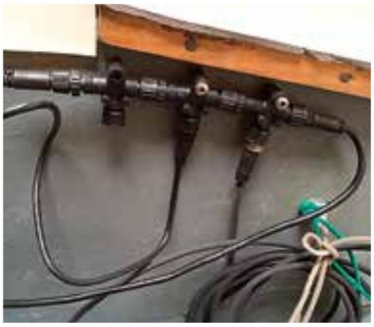
The transducer bracket fitted onto my existing masthead light bracket, with a minor modification to the screw holes.

Once the mast was up, I wired in the wind sensor using a Maretron field-installable plug, which has screw terminals for each core – I'd had to cut the plug off to get the wire down the mast.

GPS/heading sensor



As the pushpit rail was already crowded, I decided to mount the antenna below decks – which is fine on a glassfibre boat. No suitable mount was available, so I made my own from a plastic bookend, cut to shape with a coping saw and the edges sanded smooth. This keeps it out of the way just under the deck, mounted on the heads bulkhead.

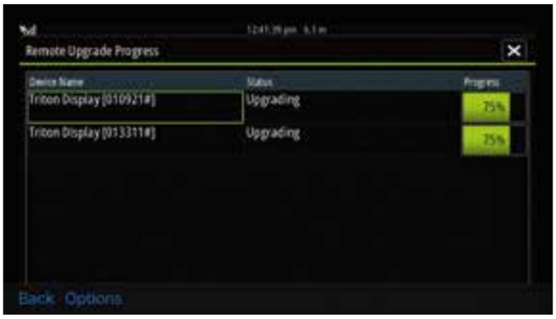


Wiring

With everything fitted, it could all be wired together as in the diagram (see page 50). It was as easy as the manual made it sound – the plugs and sockets screwed together, and all worked as it was switched on for the first time.

Software updates

With everything connected, I downloaded the latest software updates for the Triton displays and the Vulcan plotter from the B&G website onto an SD card. Placed in the plotter, this would update everything it found on the network. It's important to make sure the power stays on while it's all updating, which took around 5 minutes.



Remote Upgrade Progress

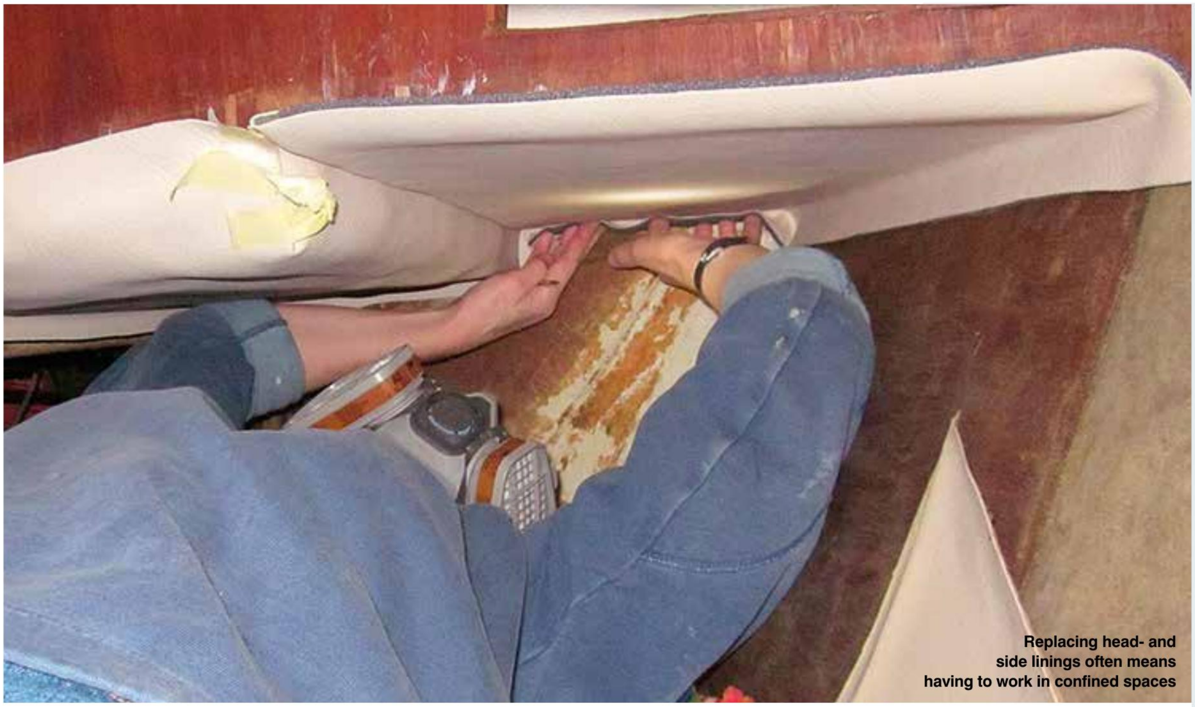
Device Name	Status	Progress
Triton Display [010921#]	Upgrading	75%
Triton Display [013311#]	Upgrading	75%

Calibrating

Finally, the last thing to do was to calibrate everything. We had luckily remembered to measure the depth offset before the boat went in the water (-1.42m). The speed could be calibrated once afloat, either by matching it to the SOG in no tide or by carrying out a calibration run. The ZG100 heading sensor required one-and-a-bit 360° turns, keeping the speed right down to enable it to get its bearings.

Conclusions

We're delighted with the new instruments. Having a small plotter in the cockpit makes edging along shallow banks much easier, and the new instruments provide much more accurate wind and speed data than our previous system.



Replacing head- and side linings often means having to work in confined spaces

Replace your headlining

Rachel and Paul Chandler show how they renewed the headlining on their Rival 38

The interior headlinings and some side linings aboard *Lynn Rival* are, like many boats of her era, finished with foam-backed vinyl. This has the advantage of providing insulation, but its big drawback is that the foam only lasts about 10 years before it disintegrates, allowing the vinyl to fall off.

Most of *Lynn Rival*'s ceiling panels are removable plywood sheets, but in other areas the vinyl is glued directly onto the inside of the hull or onto fixed plywood. We'd replaced most of the vinyl in the late 1990s and early 2000s. Although the panels around the windows were tatty, we left them at the time as they were held in place by teak trims and curtain tracks.

Lynn Rival was then based in Lefkas, Greece, and we carried out the work over a number of years during our annual working week, using the quayside as a workshop. It was sometimes a fraught process, with difficulty finding enough room to clean off the old panels, then to cut and glue on the new vinyl.

By 2012, then, not all the panels were in urgent need of recovering, but damage from our Somali pirate kidnapping ordeal in 2010 was a factor for some, especially in the forepeak where they stored their firearms and rocket launchers. Being able to remove the panels, take them home to the garage for scraping off and then to the lounge floor for cutting and gluing on new vinyl was a lot easier than it had been in Greece.

Stripping out

Not all the panels were a perfect fit and some were damaged by water ingress, so both the panels and old vinyl were marked up when dismantling, noting any problems with fit and special features like vents and light fittings. At this stage we discovered a bullet hole in the galley ceiling lining. Although we could have covered it over, the ply panel was also water-damaged so it was earmarked for replacement.

We also noted where the fixings were on each panel. Originally they had been fixed with brass screws and cups, mostly into a framework of supporting battens attached to the hull. Many of the brass screws broke when we removed the panels so over time we've replaced all the screws and cups with stainless steel, moving the fixing points to avoid broken screws as necessary.

Taking down the removable panels was the simple bit. Some are held in place by teak trims as well as screws, but in most cases it was easy to unscrew the trims, not having replaced the plugs after our previous re-covering effort. Getting full access to the panels around the windows in the saloon, galley and navigation table areas was more difficult. The curtain rails and window surrounds came down easily (often falling apart in the process – obviously in need of refurbishment!) but the starboard grab rail in the saloon stubbornly refused to come away and broke when brute force was applied: an expensive piece of teak to replace.

Scuffed and tatty headlining in the forepeak

In the aft cabin the biggest challenge was around the two coffin berths that extend underneath the cockpit seats, lockers and side decks. Some of the side panels are removable, but much of the headlining – both sides and ceilings – is either attached to fixed plywood panels or directly to rough GRP. Not only is access difficult, but the panels are odd shapes with awkward curves and angles to contend with.

The old vinyl before and during stripping

LEFT The aft cabin bunk on the starboard side. Vinyl is coming loose and the panels are odd shapes with awkward curves and angles to contend with

RIGHT The aft cabin port berth, under the gas locker, with vinyl removed

A wider view of the aft cabin bunk on the starboard side

Materials and equipment

Having established what needed to be done to gain access, the next stage was to measure all the panels, adding 100mm to each dimension for folding back at the edges, then working out a cutting schedule, adding contingency for mistakes and arriving at an overall estimate of the vinyl requirement.

I ordered 23 linear metres of 6mm foam-backed vinyl (which comes in 137cm width) from Hawke House. I also ordered copious amounts of contact adhesive, including some aerosol tins, and a small quantity of vinyl-on-vinyl adhesive. However, Alan Dring at Hawke House advised that for removable plywood panels it is sufficient to use PVA adhesive. Sceptical, but trusting his judgement – and attracted by the environmental benefits – I ordered 5lt. While perusing the product list I was also tempted into buying a small quantity of self-adhesive carpet side lining and accompanying insulating foam, to use instead of vinyl on the fixed areas around the aft cabin berths.

A carbide-bladed scraper proved to be one of our favourite tools

Other necessary kit includes scrapers, white spirit and gorilla filler for the preparation stage, good quality scissors and knives for cutting and trimming, a respirator mask with organic vapour filters – essential when working in confined spaces with contact adhesive – containers and applicators (cheap brushes) for gluing, masking tape and marker pens for positioning, a foam mini roller for applying even pressure when fixing the vinyl, and Autoglym intensive tar remover for removing excess adhesive.

Preparation

While Paul was busy in the garage creating a new galley unit (see PBO June 2013) I was in the boatyard stripping off the old vinyl around aft cabin berths, pondering how to make improvements. The ceilings and sides around the end of the berths were particularly challenging, with uneven surfaces (sometimes a mix of plywood and GRP with gaps in between), rough GRP with voids, difficult angles and internal corners-cum-steps. I removed and set aside the old pieces of vinyl, making notes.

The next step was to scrape off all the old glue. Over the following weeks and months I found that the glue would sometimes come off quite easily with a standard triangular scraper, but usually required a heavier scraper and more effort. I suspect the variation was caused by differences in the type of contact adhesive used (mostly bought in Greece) and how long it had been in place.

Sometimes I could soften up stubborn glue with white spirit and then scrape it off more easily: other times I gave up on the basis that if it was surviving heavy scraping, it would be OK to glue on top of, coarse sanding (80-grit) as necessary to provide an even surface.

It's a good idea to wear the mask when removing the old headlining as the disintegrated foam can be quite dusty, and also when using white spirit in confined spaces. Blue nitrile gloves are also necessary as they don't dissolve in white spirit in the way that vinyl gloves do. For the same reason, white spirit should not be used on the new vinyl headlining.

Gap-filling foam

In places where there were large voids I used weatherproof expanding foam filler. The cans are designed to be held upright while spraying and I was lying on my back working upwards, so it wasn't easy getting the foam to come out and go where I wanted. However, a little goes a long way and I soon got the hang of producing a quick squirt, shoving a piece of hardboard up to hold it in place, taping it up and leaving it to harden overnight. Once the foam had set I could trim it back to provide a reasonably smooth surface upon which to glue.

Elsewhere, the preparation was more straightforward – simply a time-consuming task of scraping off the old glue, mostly from removable plywood panels. Panels needing adjustment or replacement were taken to the workshop. Some of the fixed panels were adrift and I refixed those as necessary using screws and Gripfill adhesive, handy for fixing panels to uneven surfaces such as the inside of the hull.

Expanding foam treatment above the starboard berth

Gluing to fixed panels

I started with the most difficult area – above and around the aft cabin berths. The ideal procedure for fixed panels is to make a template and cut a piece of vinyl to fit, plus at least 50mm all round.

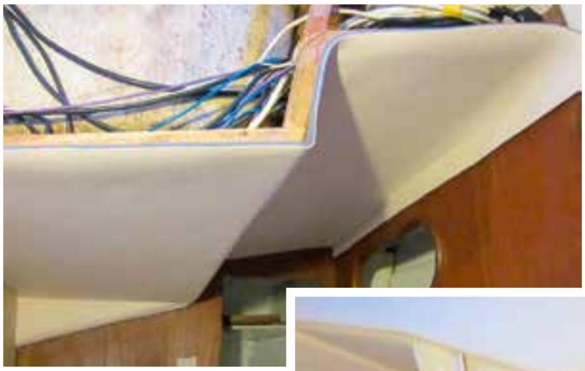
It's difficult enough to find space aboard to lay down the 137cm-wide roll of foam-backed vinyl, let alone cut out sizeable pieces of it, so I did the cutting at home, usually using the old vinyl as a basis for the template – and as a reminder not to cut the piece the wrong way up!

The vinyl should be glued in place starting with a section at the centre and working outwards to within about 100mm of the edges, then leaving it for 24 hours to settle before finishing off. The gluing process involves marking up the centreline of the area to be covered and spreading contact adhesive over it but not right up to the edges.

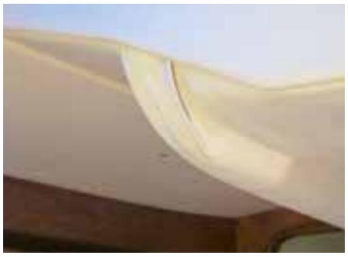
A manageable section, say 200mm wide, of the foam underside of the vinyl is then sprayed with contact adhesive. Once the glue is tack-free, this section is offered up along the centreline, aligned and smoothed into place. The next step is to spray contact adhesive onto a further area of adjacent foam, wait for it to dry and smooth it into place, then continue working outwards until near to the edges.

This approach is fine for areas that are flat with easy access, of course. In difficult areas, with awkward angles and corners, there's a trade-off between attempting to do the whole area in one piece or splitting it into several, resulting in more edges to deal with. In some situations it can be difficult to line up a big piece and the vinyl may twist or stretch when smoothing into place. One option is to allow more spare material at the edges, but this makes the whole thing even more unwieldy to handle! For these areas I strongly recommend smaller panels, overlapping at the joints, with the exposed edge turned under.

I also found that it was not always necessarily best to start in the middle, or to leave all the edges until the end. For small pieces requiring a neat, turned-under edge it was easiest to do the edge on a workbench then install it, positioning this edge first. Working on pieces that wrapped around corners where more than one edge required an overlapped finish meant I had to complete some of the edges as I went along.



ABOVE Aft cabin, port bunk, a fairly straightforward piece of in-situ headlining: but note the far edge must be finished during the process rather than at the end



RIGHT A trio of pleats above the starboard berth

The end of the starboard berth, covered with self-adhesive insulating foam

Pleating and edges

When fixing the vinyl care must be taken not to press too hard, leaving fingertip indentations when the contact adhesive merges. Having lightly placed the vinyl in position, use a foam mini roller to finish off.

Pleats are necessary in some places, for instance at the corner of the underside of the cockpit lockers. It's best to glue as much as possible of the vinyl into place, but leaving enough room to mark up the edges of the pleat and remove the excess foam. Then trim the vinyl, fold the pleat inwards and glue together using vinyl-on-vinyl glue. For uneven surfaces, pleats are inevitable as any attempt to stretch the vinyl to accommodate bulges doesn't work.

Most of the edges have to be done in situ and vary depending on whether they are to be overlapped by another panel, covered by a trim or left exposed.

The first step is to remove the excess foam beyond the edge. It helps to mark up the edge of the panel with chalk, then press the vinyl down onto it, leaving a chalk line on the foam so you can trim up to it. For trimming the foam – but not the vinyl – I use a serrated fruit knife, having learned from hard experience that with a sharp Stanley knife it's hard to avoid accidentally cutting through the vinyl as well. The excess foam can then be peeled off.

Edges that will be covered by other panels or teak trims can simply be glued down with any excess trimmed off. Exposed edges are best turned under and glued back onto the foam before gluing the edge to the panel or overlapping an adjacent panel. These are not easy to do in situ but look much better than a raw edge.

When overlapping an adjacent panel, or any vinyl-on-vinyl join, contact adhesive doesn't work, but Bostik 1782 (or equivalent) is very effective. It works by melting the vinyl and fusing it together, so any spills will spoil the vinyl surface permanently. It's essential to mask up the join to avoid this and also to support the join – with masking tape, for example – for a few hours while it sets.

Carpet and insulation

For the ends and fixed sides of the aft cabin berths I used self-adhesive carpet sidelining. The accompanying insulating foam, also self-adhesive, was excellent for covering the uneven berth ends and other gaps, providing a smooth and soft surface underneath the carpet.

The carpet was easy to cut to size and the cut edges look fine. The method of application is similar to vinyl, starting from the middle and working out for large pieces. However, there is less risk of distortion so it's unnecessary to allow so much excess for trimming. For the glue to work, the temperature of both panel and material needs to be about 20°C. I followed Alan Dring's advice of warming everything up with a hairdryer.

Finishing off the aft cabin involved re-covering a mixture of removable and fixed panels. The remaining fixed panels were much easier to access, and apart from cut-outs for locker and window or portlight openings, fairly straightforward.

One lesson learned is to use plenty of spray adhesive on fixed ceiling panels. Some of mine didn't have enough glue the first time and required a second application.

Aft cabin port side illustrating window and cubbyhole cut-outs

Re-covering the removable panels

These are relatively easy, depending on the number of corners and notches, and are best done in a clean workshop (I used the lounge floor).

After measuring out and cutting, I put down each piece of vinyl foam-side up. With the plywood panel alongside, mating-side up, I coated it with a generous amount of PVA adhesive then turned it over and placed it on the foam, weighing it down as necessary until set (overnight). The nice thing about PVA adhesive is that it's easy to spread with a scraper or brush, with no toxic fumes.

After cutting through the foam around the sides of the panel and stripping off the excess the next stage was to prepare the corners and any special features.

Previously when finishing off the corners I had simply wrapped the vinyl over from both sides and trimmed off the excess. Sometimes it worked, but often the corners tended to open out at the point. It didn't usually matter, but panels that are sometimes taken down (for access to wiring etc) are vulnerable at the corners.

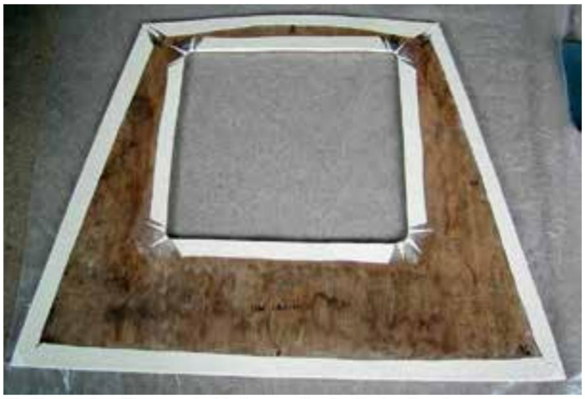
Following Alan Dring's instructions, I left a small tab at each point this time. Once the sides are glued down with contact adhesive, the tab is glued on top using vinyl glue. The result is a neat and much more robust corner, although thicker by 1mm.

Internal corners or curves, eg in a slot to allow for a hatch, have to be trimmed with great care. The vinyl does give a bit and it's possible to make a number of cuts creating pointed tabs that can be folded around the curve opening, but a wrong cut or a cut too far will spoil it. I used embroidery scissors for these fine cuts. Perhaps the most difficult is a 90° corner. Fortunately we have trims to cover all of these!

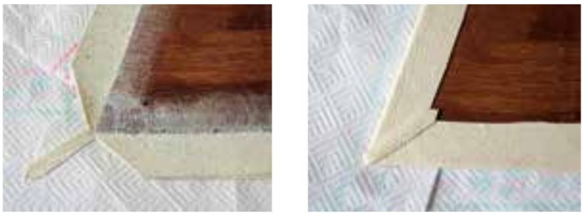
Finishing the job

We overhauled and re-covered a total of 51 panels: 27 were removable and 24 fixed. I removed any marks, mainly from contact adhesive spills, using Autoglym Intensive Tar Remover. We used stainless steel raised-head countersunk screws and cups for fixing: not the most elegant solution, but practical. However, the job wasn't complete until I'd cleaned and varnished all the teak trims.

We're very happy with the overall result. If nothing else the foam padding is nice to fall against when bouncing around in heavy seas! We're also pleased with the carpet sidelining around the aft berths – so much so that we've used a piece to replace the water-damaged veneer around the aft hatch.



The forepeak ceiling panel with the opening for the forehatch



How an external corner is made. Once the main edges are glued to the back of the panel, the tab is glued on top of them using vinyl adhesive

Looking like new: the finished linings

Neatly-finished job: the new headlining in the main saloon

ABOVE Panels installed above the navigation table, with a refurbished window surround, still awaiting side trims

RIGHT The aft cabin ceiling and side coverings to port. A blind covers the aft portlight

Much more cosy: the aft cabin starboard bunk

What the job cost

The vinyl, self-adhesive carpet sidelining and foam cost £356. In addition we spent about £150 on adhesives and consumables. Most of the tools and safety gear – mask, scrapers, saws, screwdrivers, scissors, knives, straight-edge, pencils etc – were from our toolbox and not bought specifically for the job. We've not included any costs for replacement plywood, teak trims, screws and cups.

Applying varnish

Few things look better on a boat than beautifully varnished woodwork. The best results are all down to the preparation and here sailor, cabinetmaker and antique furniture restorer Roger Oliver shows how to achieve a perfect finish

As well as enjoying sailing, for the past 40 years I have also been a cabinetmaker and have restored antique furniture, including some pieces for the British Museum, using many materials to bring surfaces back to life. I'd like to pass on a few tips to help other boat owners obtain that hard, durable varnish finish we all love to see.

ABOUT THE AUTHOR

Roger Oliver is best known to PBO readers for his 'grown-up gap year' cruise around Britain in *Jalina*, his Sadler 25. He holds a commercial RYA Yachtmaster certificate and is a 'C' rated Royal Artillery Yacht Club skipper.

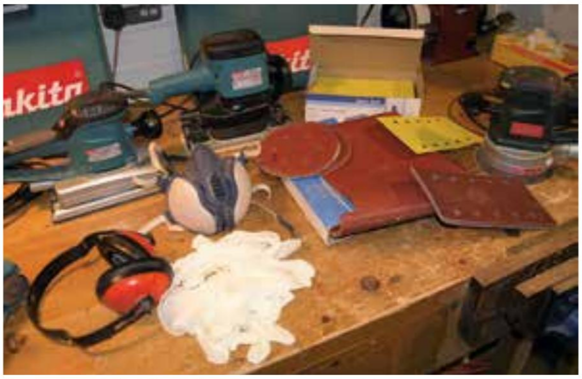
A good finish is all down to thorough preparation: skimp and you'll be disappointed. When I refitted *Jalina*, my Sadler 25, I removed as many items as possible, such as the chart table and dining table, so they could be varnished in a dust-free area at home and stored to avoid damage while other maintenance work was completed on the boat during the winter.

Jalina is sailed extensively most years, so I need a durable finish to maintain her good looks for the whole season. Hours of preparation and varnishing can be spoiled by leaving the work until just before sailing: It's much better to carry out all the preparation and varnishing directly after the sailing season, say in October, which allows the solvents in the varnish to dry off over the winter. By doing this the finish could well last for several seasons.

What you will need

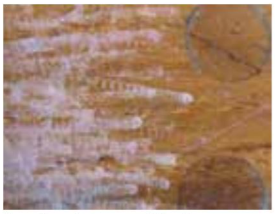
ABRASIVES It is important to use good-quality abrasives such as aluminium oxide. This is available with cloth or paper backing, or pre-punched for dust extraction using modern sanders and with Velcro backing, making grade changing more flexible. A variety of grades are available, the most widely used being 80-, 120-, 180-, 240- and 320-grit.

Cheap abrasives with poor bonding of the grit may contaminate new work, with the



A selection of abrasives, electric sanders and safety gear grit getting embedded in the grain. Pre-punched abrasive material fitted to modern sanders with a dust extraction system lasts much longer, and with very little clogging of the abrasive material a much finer finish can be achieved.

SANDERS These should only be used for pre-finish sanding: the final two coats of varnish should be completed by hand-sanding to avoid orbital sanding rings showing through the varnish with the final finish.



Sanding rings – avoid using an orbital sander in the preparation of the penultimate and final coats

There are a wide variety of sanders available, some capable of removing thick coatings to a pre-finish, with an orbit range of 2.6mm to 5mm.

Using the old type of sander without dust extraction, some clogging of the abrasive may occur. Much of this can be removed by swiping the base of a plastic bottle across the abrasive surface, or you can purchase abrasive belt cleaner specifically for the job.

BRUSHES Good quality brushes are expensive: the trade usually recommends squirrel or badger hair brushes for varnishing, but I have found pure bristle brushes from Axminster Power Tool Centre (25mm £1.61, 37mm £2.40 each) give excellent results. Use a 25mm brush for small awkward places and 38mm or 50mm for the large areas.

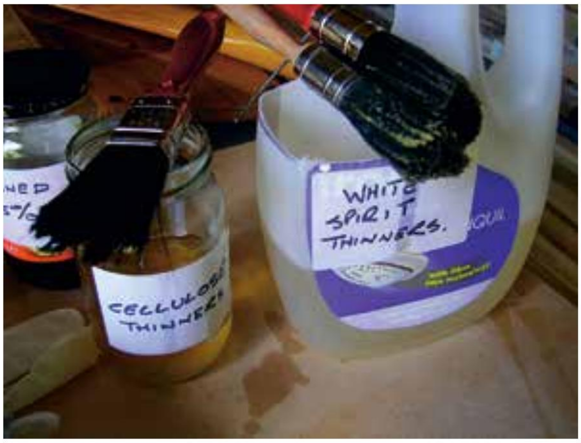
After varnishing, storing brushes in thinners for several days between coats will allow spent varnish in suspension in the thinners to coagulate and contaminate the finish for the next time the brush is used. To avoid this, store in cellulose thinners but wipe off any surplus cellulose before using the brush.

When the work is complete, clean brushes in thinners and wash thoroughly in detergent and warm water. Dry and bind the bristles in brown paper to avoid them being misshapen in storage.

DUST MASK Essential wear during all stages of sanding and varnishing, a dust mask is particularly important if you are working in confined spaces on the boat, which should be well ventilated. The 3M A1P2 EN 405 vapour respirator offers excellent protection.

LATEX GLOVES To avoid skin contact with paints and varnishes, use disposable surgical latex gloves: these cost around £4.50 for 100.

Ear defenders for sanding, a dust mask and latex gloves are essential



Coagulated varnish on a brush stored in white spirit: with cellulose thinners, however, the brush is clean and free from old varnish

VERGIN
THINNED 10%
THINNED 25%
CELLULOSE THINNERS
THINNED 25%
WHITE SPIRIT THINNERS

Varnish thinned in preparation for application

The right stuff

Avoid working from the main source of the varnish: decant what you need into a container and thin as necessary. Store all varnishing materials in a dust-free cupboard. Gloss varnish should not be stirred immediately before, otherwise air bubbles may spoil the finished surface. Matt varnish contains a matting agent, so it must therefore be stirred to ensure an even mix – after which, as for gloss, it must be left for a short while for any air bubbles to come to the surface to disperse.

A good-quality varnish will have a high solids content, while a poor-quality one can contain as little as 30% to 40% solids. The higher the percentage, the thicker the film per application. Good-quality varnishes are usually warmer looking as you build up the coats.

Traditional 'classic varnish' is easy to use for touching up damaged areas and gives a good depth of colour, emphasising the wood grain below the surface. It is also more flexible than the hard surface of two-pack products.

Most good traditional varnishes contain quality materials such a tung oil, blended to give a flexible finish with UV filters, and are suitable for external and internal use above the waterline.

If you do decide to apply a two-pack varnish on an existing coated surface, first check you are applying it onto a similar two-pack surface: it won't be compatible with ordinary one-pot varnish. To check compatibility, wipe the surface with two-pack thinners: if it affects the surface you may be faced with having to strip back to bare wood. You can, however, safely work the other way around by applying one-pot varnish on top of a properly cured two-pack surface.

Two-pack is much more difficult to touch up: it often has to be completely removed and cut back to the wood, then reapplied to get a professional finish again.

New work

New work on bare wood is best done dry, starting with 120- to 180-grade paper with a sander. Let the weight of the machine do the work: set it at medium speed and ensure the abrasive is not clogging and marring the wood surface. Use a hand-sanding pad with 180-grade, working with the grain to remove any sanding ringlets from the surface.

Dust contamination can spoil the best-prepared work: decontaminate the sanded items and surrounding area before varnishing or, even better, varnish them in a separate dust-free room. Hanging small items from

Hang small items from cup hooks to reduce dust contamination cup hooks helps to reduce dust contamination. Wearing clothes such as woollen sweaters or dusty overalls can also be a source of contamination.

Thin down the first coat of varnish for new work by 25% with white spirit, which helps it to soak into the wood. Allow to dry for several days: this first coat will take longer to dry. For the second and third coats, lightly rub down by hand with 240-grade, and thin the varnish by 10%.

Sand with 320-grade before the final coat. A tack cloth can be used to collect the very fine dust left from fine sanding: this cloth should be stored in a clean, airtight glass jar.

Use a tack cloth to collect fine dust

The number of coats applied will depend upon the wood used, its grain and the quality of finish you require. Several thin coats are better than a few thick coats: they'll dry quicker, and also to a harder finish.

The final coat can be thinned by 5%. Warming the varnish will assist its flow and will reduce runs as it cools. Avoid going back to re-brush the surface as it will soon become tacky as it cools.

Finished items will be stored to allow the varnish to harden properly

Varnishing previously coated surfaces

Previously-varnished surfaces will have accumulated dirt and grease over time, and to avoid this clogging the abrasive in the initial sanding it is important to wash it off with detergent.

A deteriorated surface requires cutting back to the wood, in which case it should be treated as a new surface. A sound surface also requires thorough preparation – sanding with 240-grade before a first coat of new varnish and with 320-grade before a final coat.

If you sand down too soon between coats the surface may roll or tear, clogging the abrasive and spoiling the finish.

Varnish should be applied in a warm, dry atmosphere: if applied to a damp surface, the result will be an opaque bloom finish.

First apply across the grain then finally lay off with the grain: be methodical in the sequence and don't spend too long brushing the varnish flat because the surface will soon become tacky – let the solvent help with the job of flowing the varnish.

Tackling teak

Teak, being particularly high in oil content, will shed varnish easily without pre-treatment. The surface of teak must be purged of oil for varnish to key to it: this can be done by rubbing it vigorously with a liberal coat of white spirit or cellulose thinners, then applying a thinned first coat of varnish as for a new wood surface.

The natural oil present in the teak will eventually soften the varnished surface and will require a periodic light rub-down and re-varnish.

The engine cover prepared for its final coat of varnish

***Jalina*'s finished engine cover, in position with a pleasing shine**

Brush up on the main points

- **Carry out the varnishing soon after lay-up, in the late autumn, for a more durable finish next season**
- **Use cellulose thinners to store brushes for a short time**
- **Decant enough varnish for the job and store the source container in a dust-free area**
- **After use, store a tack cloth in an airtight container**
- **Don't try to brush the varnish flat – the solvent will assist the flow**

- **Warm the varnish in a bain-marie to assist the flow**
- **With teak, purge the surface oil before varnishing for a better key**
- **Varnish in a warm, dry atmosphere**
- **To avoid bloom, ensure the surface is dry**
- **Use cup hooks for small items – hanging vertically reduces dust contamination**
- **Varnish the area to be covered in small square sections. The adjoining edges will still be relatively fresh and the varnish will flow together correctly**
- **Regularly put your (dust-free) head close to the varnished surface and look along it for areas you may have missed. Oblique lighting will also help here**
- **With classic yacht varnish, if you are able to apply a coat every 24 hours you can rub down between coats with a felt pad and whiting (fine chalk dust). This is enough to key the surface but is not as abrasive as sandpaper, allowing you to rub down while the varnish is less hard. Clean the surface after rubbing down with a tack cloth**

Maintaining your marine gas system

Peter Draper explains what's required for a marine gas system to be safe and legal, and how to assess the condition of the gas system on your boat

Is the gas on your boat safe, legal and insurable? Will it satisfy your marine surveyor and insurance company? When was it last tested or inspected, and do you know who installed it? Usually that would have been the yard that built your boat, and hopefully it would have been installed to a high standard. Apart from routine maintenance and inspections, it should never give cause for concern.

Then there's the work, rebuilds and alterations done by the skilled amateur. Although uncertified and not strictly legal, their workmanship should not cause any significant issues. The problem is when work is carried out by enthusiastic but completely unskilled have-a-go guys. Systems like these, and those that haven't been inspected for years, are the ones we should be concerned about.

Those of you with your keels in the fresh water of the inland waterways are bound by the rules of the Boat Safety Scheme and will have regular inspections carried out by a qualified inspector. As yet, however, there is no such requirement for privately-owned coastal and seagoing vessels, so unless your surveyor or insurance company asks for a gas certificate your gas safety could be reliant upon poor workmanship carried out years ago.

Before every capable and practical boat-owning engineer emails to shout loudly that working on your own vessel is not illegal, I will refer the interested reader to the Gas Safe website: 'if you're going to pay to have gas work done on your boat, make sure the person doing it is qualified,' and from Gas Regulations, 'no person shall carry out any work in relation to gas fittings or gas storage vessels unless he (or she) is competent to do so'.

Some may believe that if it's your own boat and you're not receiving payment it's not illegal, but if you've never been trained in gas installation and you're not registered, how can you or the person doing it on the cheap be competent? You or they definitely won't be insured, nor can either of you issue a legally-binding Gas Safety Certificate.

The bone yard – corroded regulators, seized valves and a piece of automotive radiator hose used as a gas pipe

ABOUT THE AUTHOR

Marine gas engineer Peter Draper (Nautigas), City and Guilds qualified for over 40 years, first took a boat to sea aged 10. He is a sport diving boat skipper and an HSE3 commercial diver, and for over a decade owned and restored a 1927 Dunkirk Little Ship, *Caronia*, based in Chichester Marina.

Rogues' gallery

Over the years I've seen a rogues' gallery of incorrect pipe used, corroded pipes in wet bilges, low-pressure hoses on high-pressure systems, water fittings and taps, natural gas fittings, steel hydraulic fittings, hoses out of date by entire decades, gas pipes clipped to engines, bits of car radiator hose and, the worst yet, plastic push-fit pipe used as a gas line. Quite simply, whether it's fittings, hoses, regulators or valves, if it's not LPG-approved and marine-grade, it should not be used on your boat.

Take a look at your system. One indicator of a DIY installation is the lack of a test point, which means the system cannot have been tested to the correct standard. Look for worm drive clips – some are totally unsuitable for LPG pipes – and look for an absence of clipping on copper pipework. Both shout 'DIY installation'. Parallel thread fittings are the worst: soft solder fittings are not allowed. Certain fittings just won't keep LPG in, no matter how much paste is smeared round the joint.

For other indicators of a poorly-maintained system, look for long-out-of-date hoses: there will be a date printed or stamped on the hoses, and they should be less than five years old. Unfortunately, many vessels are

Armoured hose has a data and date badge attached

fitted with 'camping'-grade regulators, and may have been so since new. They are usually blue for butane and red for propane. They are just not designed for the harsh conditions of the marine environment: they are not marine-grade materials, and don't have a safety pressure relief valve. When they corrode internally and externally, they become incapable of regulating the gas pressure. I've found butane regulators rated at 28Mb passing over 40Mb: it doesn't boil the kettle any faster, and it's not safe for the eyebrows.

New marine-grade regulators have a pressure relief outlet for safety

A typical gas system

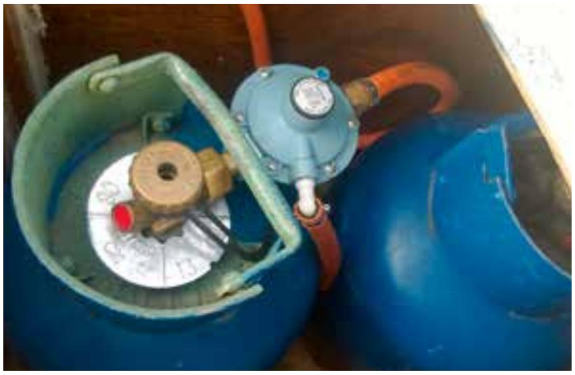
At the heart of a typical gas system on a boat, as found on 95% of the vessels I work on, would be a cylinder in a locker which should be gas-tight. This means that should there be a leak from the cylinder, the gas cannot enter the vessel by any means.

From the locker there should be a drain, preferably straight overboard: there is a relationship between the size of the drain needed to the size of the cylinder stored. Most lockers are made from the same material as the vessel and are often an integral moulding. Some have a gas-tight door to access the cylinder, but most allow access from the top only.

There should be some method of securing the cylinders, and the locker should be big enough to contain both the cylinder in use and any spare carried. Don't, as I have seen more than once, keep the spare cylinder under the guest bunk.

This gas locker has a side door to allow access

The gas in the cylinder is at very high pressure in relation to what is required by the appliance (the cooker, in most cases). A regulator is used to reduce this pressure. The latest marine regulators are now fitted with an over-pressure 'vent' to ensure the pressure inside the regulator is not any higher than it can cope with. Some systems will have the regulator mounted on the side of the locker and a high-pressure hose running from it to the cylinder. Some have two high-pressure hoses, attached to dual cylinders and selected by a changeover valve. These hoses are usually black rather than the commonly seen low-pressure orange hose. The regulator directly onto the cylinder system will have the low-pressure hose connecting it to the pipework entering the boat. This hose should be connected with O-clips or swage fittings. The advantage of the high-pressure system is that there are adaptors available to connect to most cylinders worldwide, and the twin changeover means not having to swap the regulator to the spare, just moving the valve over. The downside, as always, is cost. BSS-applicable boats usually have a 'bubble tester' after the regulator.



This is a new installation, with the regulator fitted directly on the cylinder with an O-clipped hose

Bubble testers will show up leaks

The main pipe through the boat is LPG-grade copper, much thicker than domestic-grade pipework. It should ideally leave the locker higher than the regulator or cylinder and be sealed through the bulkhead. It should be clipped throughout its run with suitable clips to prevent damage or abrasion. The pipe will usually terminate at a quarter-turn shut-off valve near the appliance, and any moving appliance such as a gimballed cooker will have the final connection made via an armoured hose. Lastly, but most importantly, there should be a test point tee at the appliance.

One final variation on this set-up is the use of an electronic solenoid to shut off the gas. The idea is that you can leave the gas on at the cylinder and, from a location close to the cooker, turn on the gas via an electronic switch. They can also be activated via a gas alarm, which will automatically turn off the gas if it detects a leak.

Common sense

Using your system safely is common sense: only turn the gas on at the cylinder when you are going to use it, and make turning it off again a matter of habit. Ensure you have adequate ventilation, which means opening a hatch or portlight. Never use the cooker for space heating. If your cooker is old it won't necessarily have flame failure devices that shut off the gas if the flame goes out, so never leave it unattended. Poorly-maintained or even dirty cookers can cause poor burning of LPG. A rusty grill fret/mesh is a very efficient producer of carbon monoxide.

Gas alarms, whether stand-alone or linked to a shut-off solenoid, are a good idea. The stand-alone ones are by no means expensive, and a practical owner will find them easy to fit: they're certainly no more complicated than (highly advised) carbon monoxide and smoke alarms. If you follow the manufacturer's instructions as to where they should be fitted, they can be put up with a couple of screws each: but remember to test them regularly.

Getting the job done

So, who can legally work on your boat's gas? It will be someone who is qualified, registered and insured to do so, which means someone who is Gas Safe registered, someone who has undertaken core LPG gas training and the additional boat qualification. Ideally, someone who has specific marine insurance and experience of working on boats.

Ordinary domestic plumbing and gas insurance will not cover marine work, and the idiosyncrasies of boat gas are very different to LPG in caravans or domestic properties. Only a qualified and registered engineer can issue the Gas Safety Certificate. As we know, your BSS inspector can test your gas by the bubble tester, or if they are trained and Gas Safe registered they can break into the system and use a manometer, which by its very nature is classed as 'gas work'.

Your gas engineer will be able to advise you as to best practice, then install and test the system to the required standards. They should have the necessary test equipment to pressurise the system to above its working pressure, and should test all pipework and appliances on air and on gas. They should check all safety devices, flame failure devices, carbon monoxide risks, ventilation and, if relevant, flueing. Much of the knowledge and equipment required is way beyond the scope of even the most competent and practical owner. My own electronic manometer will measure down to 0.1 of a millibar: that's about 0.0015 PSI, or about 1/20,000th of the pressure found in the average car tyre. So when I sign that the pipework is gas-tight, it is!

Carbon monoxide testing is of vital importance

Peace of mind

Practical-minded boat owners can do a lot themselves. Take a boat that has no gas at all, or which has had to have its substandard gas installation removed: the practical owner, following a discussion with the gas engineer, could quite capably and legally install the gas locker, drain, cylinder restraint, cooker gimbals, cooker and any ventilation requirements. I would be happy – and it's my name on the certificate! – for the owner to install the copper pipe run through the boat, providing it was the correct grade of pipe, it was to an agreed route, it was correctly clipped and had no joints. I, the gas engineer, could then use the correct fittings and procedures and actually connect and test the gas. That's going to save the gas man a lot of time and the owner a lot of money.

Is it expensive to use someone like me? Well, once brought up to standard, the ongoing checks and hose changes would cost no more than a three- or four-night stay in a South Coast marina. A small price to pay for peace of mind, a safe and legal system and that all-important Gas Safety Certificate. Next time you're putting the kettle on, it's milk and one sugar, please.

Pressure-testing to regulations

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Flushed with success

David Berry describes the process involved in servicing his boat's toilet

There are some jobs you just don't want to do, but after a while, when the shrieking gets to a pitch where earplugs and noise-cancelling headphones won't work – and where however many glasses of wine you pass across the table to your ever-loving partner, her squealing also won't stop – you just have to bite the bullet and get the gloves out.

In truth, servicing your boat's toilet isn't going to be as bad as changing the average baby's nappy. On the other hand, if you've not yet had that pleasure, then changing the average baby's nappy is worse than cleaning out the toilet; so that's a little something to look forward to...

Hygiene

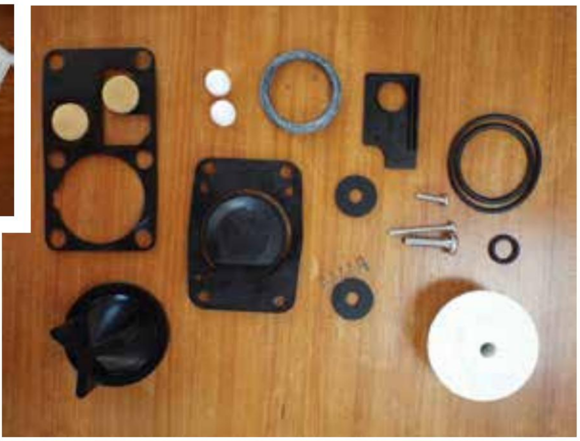
You're dealing with bacteria, most of which came from you in the first place, but not bacteria which you want to spread around the place or ingest – so start with hygiene.

Firstly, if the local regulations allow, flush the toilet through with whatever sterilising product meets the rules in force in your location and situation. Since we were in a harbour when we carried out the toilet service, we were unable to flush through with anything other than seawater. We did, however, spray all the external surfaces with an anti-bacterial surface spray: we kept this within reach throughout the entire operation and used it liberally on all the parts as they became exposed, the tools we used to expose them, the nearby sink we used as a bench, and so on...

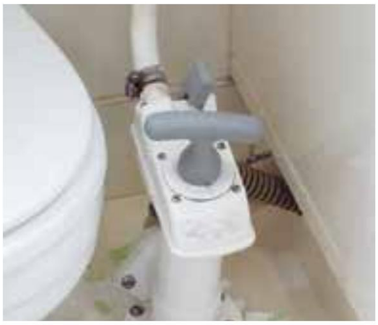
Disposable nappies are designed to absorb many times their weight in water and brown stuff (I know: babies again!) and we use them regularly on board for such tasks as bailing out bilges and catching oil spills during oil changes, so nappies were our first choice to pack around the base of the toilet pump to contain any escaping liquid.

Finally, we chose to use disposable gloves. It probably doesn't need saying, but it's best to have a supply of these to hand, not just one pair. When you've finished the job, wash down everything your gloves have touched – including tools, door handles, valve handles and anything else – with a disinfectant solution which you then need to dispose of properly (absorbed into nappies, put into bin bags and then in rubbish bins, perhaps – not flushed overboard).

We began by first emptying the toilet and the pump, leaving the handle in the evacuated position to minimise the amount of water we would have to deal with. Then we closed both the inlet and outlet valves. It's arguable that if you have siphon breaks you won't need to do this, but I wasn't taking chances.

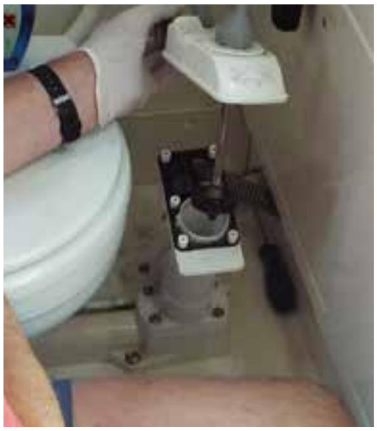


The kit contains everything you need including the top and bottom valve sub-assemblies, O-rings, seals and a Joker valve. As you take each sub-assembly apart, have a good look at the way each seal, valve or other component is oriented and fits into its location so that you can position the new one the same way

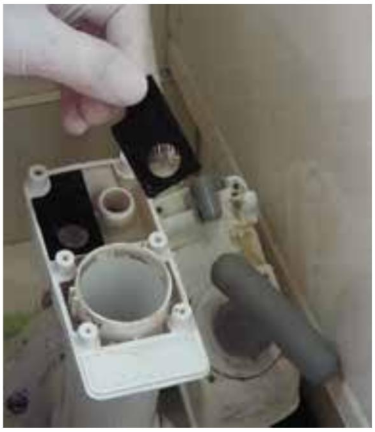


1 Start with the head of the pump. Remove the six screws at the top to expose the seawater side valve assembly.

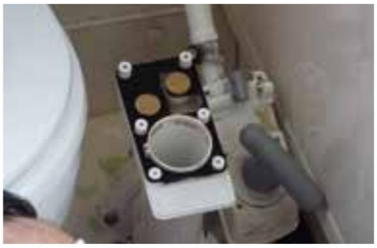
■ *The screw threads have two starts, and it's really important when you replace them to turn them backwards to feel for the thread start and then, if they seem too tight to screw down, turn them backwards another half-turn until the other thread starts. This sounds pedantic, but if you don't take care with this the screws will recut the thread in the hole and eventually all the thread will be lost.*



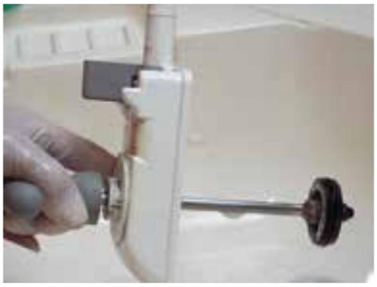
2 The handle, piston and upper housing are one assembly and came away together, leaving the rubber valve assembly on top of the cylinder.



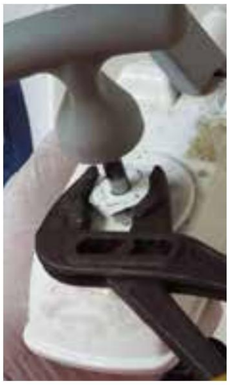
3 The valve assembly simply lifts off, leaving behind the stiff plastic shield. I only had to swap the old one for the new one from the kit, which simply dropped into position.



4 Then the new rubber valve assembly fits over the screw spigots. The brass weights are uppermost, and its asymmetry makes it impossible to fit incorrectly. I ran a smear of Vaseline around the edge to help the seal find its position when the housing was replaced.

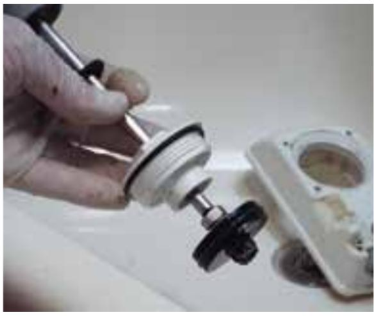


5 The housing, pushrod, piston and handle are a sub-assembly that I had to strip down, but first I sprayed it liberally with disinfectant.

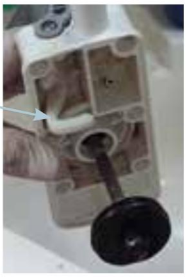


6 The pushrod bearing and seal sit inside this plastic cap, which was easily removed with a spanner. To remove the pushrod I first had to remove the handle, which was simply a case of holding the rod tightly and unscrewing it.

7 The kit contains a new piston O-ring – the fattest one in the pack. The correct way to remove any O-ring is to pinch it between finger and thumb until there's enough of a bulge to let you pull the whole thing out of its groove. Never lever an O-ring off with a metal tool or cut it with a knife while it's in position, since any scores in the O-ring groove will compromise the seal.

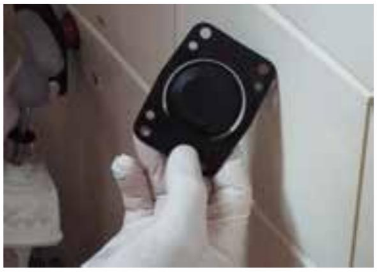


8 The newly reassembled piston looked like this, with the new O-rings on the piston and around the top of the cap.



9 With everything cleaned up and new seals fitted, I replaced the housing. The selector switch must be moved to the position shown here to enable the actuator to slip under the valve as the housing is positioned. At this point I covered everything with oil. We now use simple olive oil as the toilet lubricant since it seems to be more tenacious than the mineral oil we previously used, as well as being biodegradable in the holding tank.

10 At the bottom of the cylinder is another valve, and this one allows waste to be drawn up into the cylinder bore. Replacing it was a straightforward matter of removing the four cylinder-retaining screws then swapping the old rubber assembly with the new one from the kit.



11 The bottom valve assembly has a weight in the centre and an asymmetric arrangement of holes to prevent us fitting it the wrong way around. This one also got a little smear of Vaseline to help the seal bed into its location.

We had some bits left over. The kit includes seals and springs that service the switch on the upper housing (the one that selects between drain and flush), but we decided the switch was working perfectly so we didn't need to service it. There are also some spare screws and covers which we didn't need. The pack also includes a Joker valve: ours had been recently changed, so we put the new one into store.

12 Finally we opened the two seacocks, checked the toilet for leaks and cleaned up.

How to get a great paint finish

To create a fantastic, mirror-like paint finish on your glassfibre boat you'll need a smooth surface underneath. Here Jake Kavanagh and Richard Jerram show the secrets of surface preparation, undercoating and applying a topcoat

The secret to a lovely, glossy paint finish on your boat's hull is all in the preparation – and that means going back to basics.

The first job is to thoroughly clean the hull, starting with a wash-down with a degreasant (most paint manufacturers have their own) and then abrading it with a 220/280-grit sandpaper until you have a matt finish all over.

Fittings within the area to be painted can either be masked off or removed altogether. Scratches and damage can be filled and faired with an epoxy filler.

Rubbing down with a wet-and-dry paper (used wet) will keep the dust to a minimum, but the 'mud' of pigment left on the hull will need to be carefully wiped off. Sanding dry creates dust that will need to be removed, by washing with warm soapy water (decorators' sugar soap is very effective) or by wiping down with a tack rag, once the hull is dry.

Ideal conditions

While a few lucky boat-owners will be able to paint in a covered shed, with relatively stable conditions, most of us will be outside and may be working in variable temperatures. Two-pack polyurethane paints hate humidity as moisture reacts with the curing agent. On a good day, however, the paint does dry quite quickly – especially in direct sunlight or in a fresh breeze. A warm, cloudy day with low humidity will be perfect. Try to get the paint on around mid-morning, which is when the atmosphere will be at its driest.

Choosing colours

Some boat-owners take a repaint as the opportunity to change the colour of the hull, and experiment with a line drawing of the boat (or a trace from a photograph) to see what will work. However, your final choice of gloss will need the right undercoat to ensure the proper depth of colour. Our dark blue boat would need a blue undercoat. Lighter colours generally use a white undercoat.

Masking off

Waterlines, or areas covered in non-slip, need to be masked. For a really clean, crisp line, use a special painters' tape, such as 3M's 218 Fineline masking tape, which is made from a water-resistant plastic. The standard painters' tape as found in DIY outlets shouldn't be left on for too long as it absorbs moisture and is very difficult to get off once it has dried again.

Once mixed with its curing agent, polyurethane two-pack paint dries quickly, especially in temperatures above 18°C (64°F). This means that the job can be done in short order, but it also means you can't really stop – otherwise you end up with a hard edge in the paint.

The real key to success is to have two people working (or three on a big boat) where one is rolling the paint on, and the other is following and 'tipping off' (flattening the rollered paint gently with a brush). A third person would be preparing and mixing paint. You don't want to have to stop for more than a couple of minutes, so have everything you are likely to need ready, and make sure you can reach all the areas to be painted in one hit. Even the time taken to reposition a ladder, or to mix up some more paint, could leave you with a hard edge to your paint, which will show up.

Small boats can be painted single-handed, but you're likely to have a touch of arm-ache by the time you reach the end.

The second undercoat, or 'satin' finish

Once the first undercoat has dried, it needs to be lightly abraded using 280-grit wet-and-dry. As before, remove all the dust. You'll notice imperfections – some brushstrokes, or a missed scratch – all highlighted by the paint. Fill and fair again, and it's time for the second undercoat.

International Paint recommends making this second coat a 50:50 mix of undercoat and topcoat. This will give a satin finish, which will make any remaining imperfections easier to see. It will also give even more depth to the final gloss coat.

Because the topcoat is a 2:1 mix, and the undercoat is a 3:1 mix, you have to prepare the two paints separately, activate them, and then mix them together.

Once the satin coat has dried, it needs rubbing back with 400-grade wet-and-dry, ready for the piece-de-resistance: the two glossy topcoats.

Painting the superstructure

Much the same process applies to painting the cabin and decks, although you will need a smaller brush and will have a lot of cutting in to do. You'll find it's not quite so easy to avoid a hard edge, especially where there are lots of breaks in the paint. Removing deck fittings helps to minimise hard edges and hence runs.

General conclusions

Compared with ordinary yacht enamel, two-pack paints are slightly trickier to use, but give excellent, long-lasting results. Preparation is the key – even more so than with single-pot paints – and wastage is hard to avoid to begin with.

For a perfect finish, do the job in a boat shed, in moderate temperatures during the spring or the autumn. Painting outside, especially in the heat of the summer, can be a little more challenging.

STEP 1 Cleaning and preparing the hull

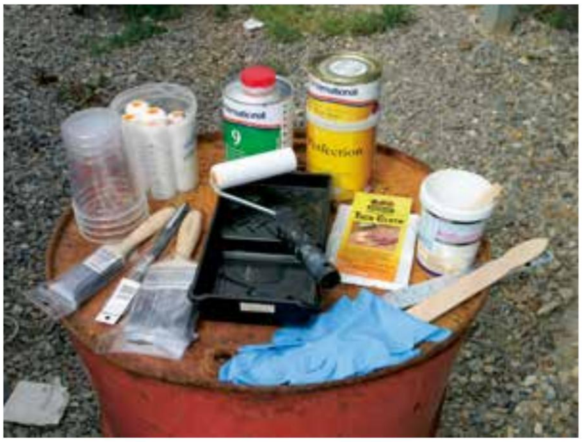
1 Wash the boat down to remove surface dirt. Several paint manufacturers produce their own degreasant and cleaners. The aim is to remove all traces of contaminants such as oil and grease that could prevent proper adhesion of the paint.

2 Sand down the surface with 180-220-grit sandpaper. Accessible areas can be done with an orbital sander, but tight corners should be attacked with a sanding block. You need to get rid of all the remaining shine in the gelcoat, and end up with a completely matt finish. NOTE: it's often best to use a wet-and-dry sandpaper (by hand – no electrics) as this reduces the amount of dust being produced.

3 Brush the dust off with a soft brush, before wiping down with a tack-rag (tack-rags are cloths with a sticky surface, so dust is held in the fibres rather than simply redistributed).

4 Holes, gouges and scratches can be filled with epoxy filler, which should be formulated to provide high strength with good sanding abilities. International's Watertite has two components, which have to be mixed in a 1:1 ratio. Only mix what you can use in the 20-30 minute drying time. Lightly sand around the scratch, and remove the dust before applying the filler. Deep, narrow scratches can be chased out with a power tool such as a Dremel. Slightly overfill, so you can sand back later. Use a coarser sandpaper, such as 120-grade, for sanding back filler.

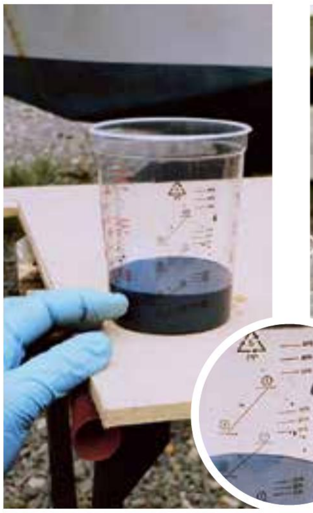
STEP 2 Preparing the undercoat



1 Tools of the trade: paintbrushes, high-density foam rollers and paint tray, flat mixing sticks, vinyl gloves, thinners, graduated measuring and mixing pots and tack-rags.

2 The tin of base paint is supplied two-thirds full, and is mixed at a ratio of 3:1 with the curing agent, which is a clear fluid.

3 Use a flat, scrupulously clean stick to stir the pigment, ensuring you lift the material that has settled at the bottom of the can.



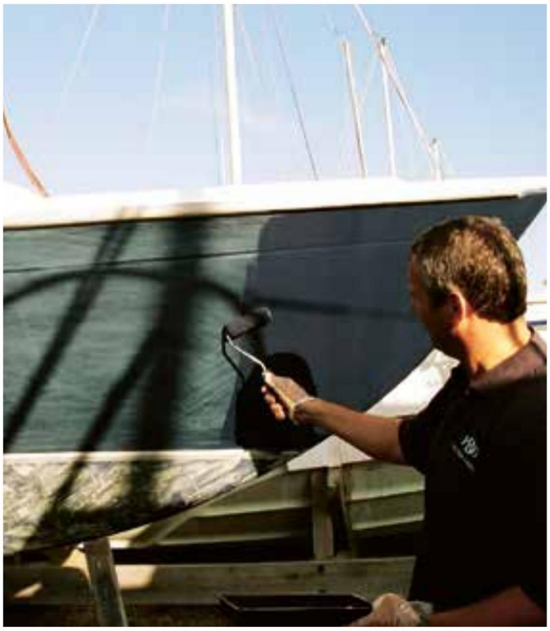
4 Use a graduated measuring cup (readily available from chandleries) to mix the ratio. Thinners can be added up to a ratio of about 10% – useful on 'quick-dry' days of sunshine and a breeze.

5 Thoroughly mix the ingredients, using a dipping and lifting motion rather than just stirring round and round. Pour workable amounts into the rolling tray, and load up the roller.

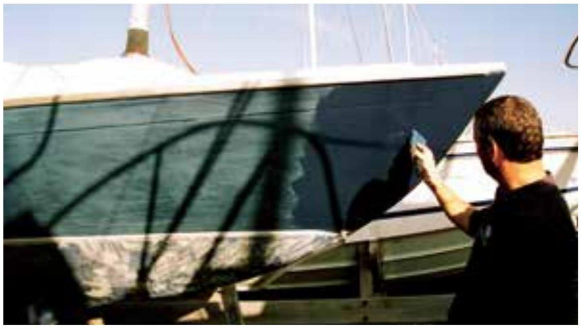
STEP 3 Painting the first undercoat

BEFORE YOU PAINT

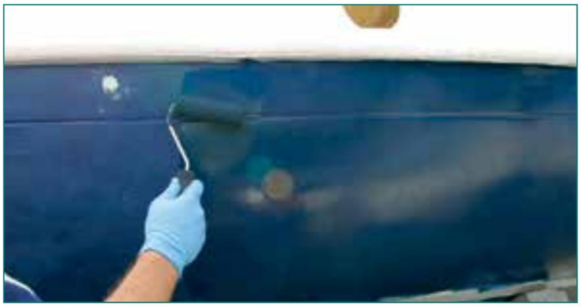
- Never apply paint directly from the can, as you will introduce contaminants to it.
- Be prepared to change brushes every 20 minutes or so. Dunk the used one in thinners to stop the paint hardening.
- Undercoat contains a lot of pigment and needs thorough stirring, especially if it's been stored for a while.
- Decant the amount of paint you expect to use into a separate container.
- Dampen the ground around the boat with a sprinkling of water to stop any dust from being kicked up.
- The thinners used with two-pack paints are specialised and expensive – but necessary. Cheaper alternatives such as white spirit won't work. Always read the labels.
- If you are running out of paint trays, or are concerned about landfill, just cover a tray with a plastic bag and pour the paint into this. You can then dispose of the bag after use, and reuse the tray with another bag.
- International Perfection has been formulated for application with a closed-cell foam roller, followed by a good-quality tipping brush (below). Have at least two large tipping brushes handy, and keep them slightly moist in No9 thinners. After cleaning with solvent when finished, wash them out with soapy water. Slightly worn brushes can often give better results than new ones.



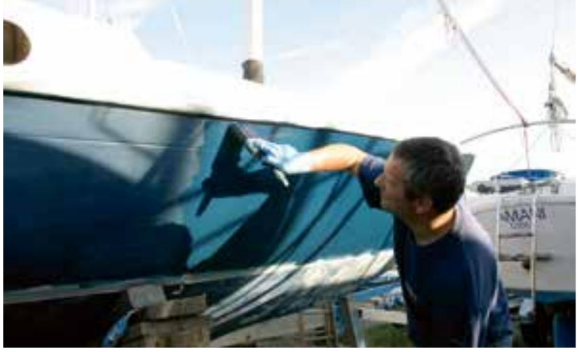
1 Working from right to left (if you are right-handed), roll on an area of paint, rolling both horizontally and vertically to get good coverage.



2 Follow up with a tipping brush, brushing with downwards strokes. The brush should neither add to or remove paint from the hull, so make sure it's not too dry. Gentle pressure works best – don't be shy.



3 Roll on the next section of paint, slightly overlapping the leading edge from the last section. Just keep going, right round the hull. Have a second roller ready to go after about 20 minutes. At the corners of the transom, use the tipping brush to seamlessly merge the paint as it laps around the edge.



4 Awkward areas such as under the gunwale may need a touch-in as you go because the roller tip is flexible, and may not fully cover this area.

5 The undercoat should be touch-dry within 20 minutes or so (depending on temperature), but leave it until the next day before sanding it down with 280-grade wet-and-dry. Wipe down with either a damp cloth or with tack-rags to remove all the dust, then apply the second coat of undercoat, mixed with topcoat. Finally, abrade the second undercoat ready for the topcoat.

STEP 4 Preparing for the topcoat

Two-pack polyurethanes are tough but sensitive beasts.

The curing agent, a clear liquid in a separate can, has to be mixed at the precise ratio to set the paint off.

High humidity (over 70%) could cause 'blooming' which is a loss of gloss surface.

The paint ideally needs to go on at 15°C-20°C (59°F-68°F).

Preparation is the key

Previously, we had:

- Sanded the hull.
- Faired all the gouges with epoxy filler.
- Applied two coats of undercoat to give depth of colour and to avoid patchiness in the topcoat.
- Flatted back the final undercoat and then washed the hull down to remove all the dust.

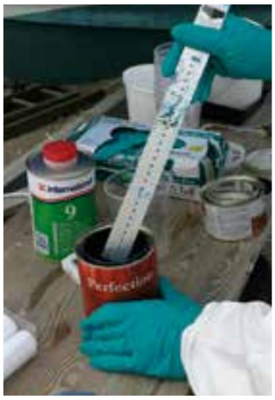
As our boat was staying blue, we used a blue undercoat – but had we changed to a lighter colour, two coats of white would have been used instead.

Before you paint

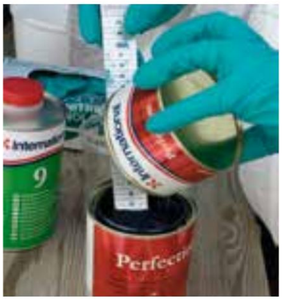
- All of the areas to be painted must be instantly accessible. You need to be able to keep moving and don't want to waste time repositioning ladders. If a wet edge of the paint goes hard, it will leave a visible ridge.
- Have all your tools to hand. Make sure you have enough paint trays, enough paint, and spare rollers and tipping brushes ready to go.
- Down with dust! Saturate the area around the boat with water to stop any dust rising, and try to pick a day when there's no wind.
- Check the masking, as tape can be dislodged or damaged during the painting or curing times, so just check it's all still in place.
- Give the gunwale a wipe with tissue just to ensure that all residual moisture from the wash-down has been removed.
- Wipe any dust or grease from the paint trays using thinners.

Saturate the area around the boat with water to prevent dust rising

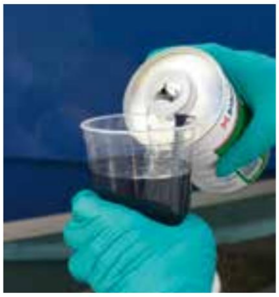
STEP 5 Mixing the topcoat



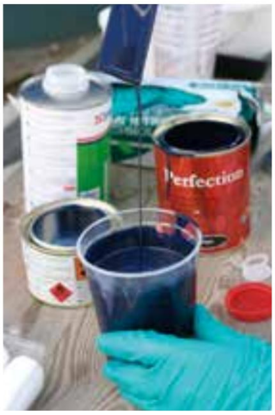
1 Open both cans and stir the base paint thoroughly as the contents settle with storage. Always use a clean stirrer. A flat, ruler-type stick works best.



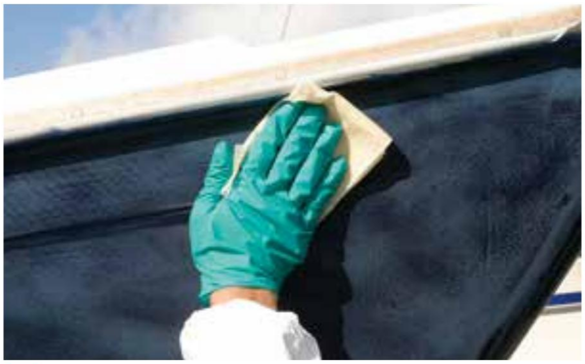
2 Add the curing agent. The tins of base colour are deliberately only two-thirds full, so you can tip the entire curing agent into the main tin for the right ratio. For smaller amounts, use a measuring cup which has the ratios marked on the side. Stir well and in a random pattern. The curing agent has to be thoroughly mixed with the base.



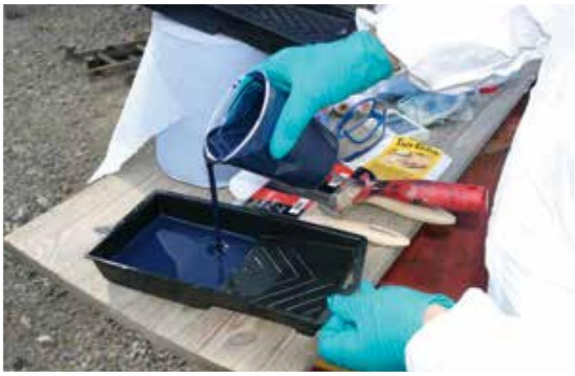
3 Decant the amount of paint you think you'll need into a measuring cup (you'll have discovered from the undercoating stage how far the paint will go, and can become quite accurate). Add between 5-10% thinners depending on how warm the day is – the warmer the day, the more thinners. We used a ratio of about 8% thinners.



4 Again, stir well. Lifting the stirrer out and letting the paint fall back in will show how consistent the mix is.

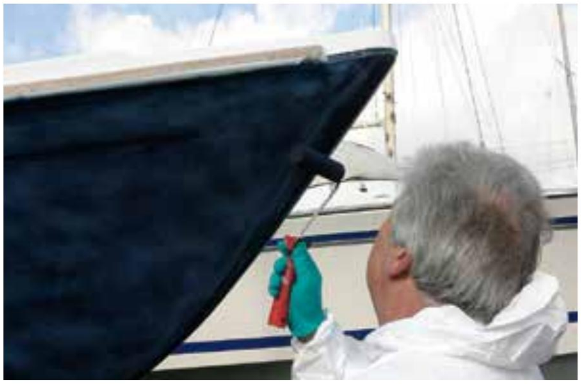


5 To minimise the chances of dust settling on the hull, give it a final wipe with a tack-rag just as you are about to paint. The tack-rags contain a wax, so only wipe them gently over the hull. Put on too much pressure, and the wax is transferred to the glassfibre, which could interfere with the finish.

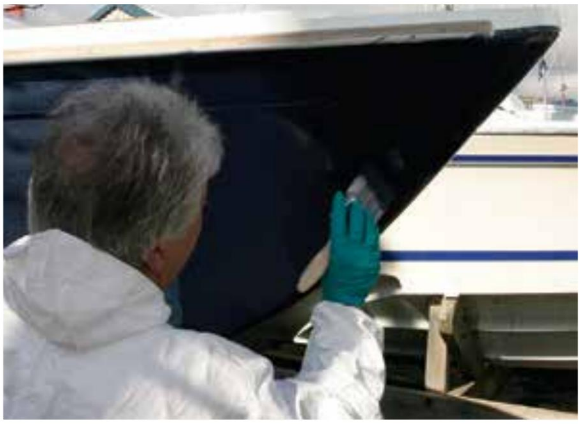


6 Pour enough paint into the paint tray so it reaches to the edge of the incline. Dip in the tipping brush so the ends are pre-primed, and load up the roller. Move everything you need close to the hull.

STEP 6 Applying the topcoat



1 If you're right-handed, start from the right. Begin at a hard edge, ie the bow, and be prepared to end at a hard edge – the transom. You won't be able to stop for more than a minute or so along the hull, or the wet edge of the paint could dry. Roll the paint on by driving the roller in several directions for an even coverage.



2 Now work the tipping brush across the paint, diagonally at first, and then finishing with downward strokes. The idea is to remove all the 'orange peel' effect from the roller.

3 Start the next area a few inches beyond the wet edge, and work back to it. This allows the roller to empty some of the paint before it hits the wet edge again, and gives a more even coverage.

4 Work the tipping brush right across the area, especially over the seam between the panels of paint. Finish off again with the downward strokes.

5 Keep going, rolling vigorously, and then quickly tipping off. Note how Richard is holding the brush, using all his fingers for greater control. If you need a comfort break, stop at a natural junction. You may decide to call a halt here and start again a following day. The bow and quarters form a natural break line, and some hulls will have other places you can stop. If you decide to keep painting, the tipping brush can be used to merge the paint seamlessly around the corner.

6 By the time we had done one side of the 21-footer, which only took Richard about 30 minutes, it was time to change rollers, as the first one was starting to soften and lose its shape.

STEP 7 Cleaning up when you've finished

Unfortunately, there can be a lot of wastage with two-pack paints. Unused activated paint just has to be allowed to go hard before being binned – it can't be poured back and reused like ordinary paint. Rollers are also deemed one-use. Brushes, however, can be thoroughly cleaned out with solvent, (it has to be the right solvent, such as Thinners No9) and then washed in warm, soapy water before being allowed to dry.

The gloss coat should be left until the next day before being wiped over with a Scotchbrite scouring pad and then recoated. There is no variation in the thinner ratios or mix, and the second coat will add extra depth to the first.

If the job has been left for a while, the topcoat will need a gentle rub down with 400-grit (perhaps 280-grit to flat off any runs) before recoating.

Masking tape should be removed as soon as possible, and is one of the satisfactions of the job. International Paint advises that the final gloss coat is left otherwise unmolested for about six days for it to fully harden, so avoid having the boat lifted or moved until then. Solvent can be disposed off at the yard's solvent bin.

Et voilà! Although our rubbing down of the undercoat hadn't been quite up to Richard's standards, he achieved a superb finish in a very short time. We used about 500ml of paint for one coat on the 6.4m (21ft) hull, and she looks great. The 80-micron layer of gloss will cure back to just 40 microns, which is why a second coat is recommended.

To keep the gloss in good order, all we have to do is wax the surface at the start of every season with a UV-resistant wax. The cost of materials for this small boat was around £250, including rollers, paint trays and tack-rags, and if the gloss lasts for the five to seven years as claimed, that's not a bad investment.

Obviously, a lot of time was spent in the preparation, but when you see the results sparkling in the sunshine, you sort of forget about all that.

Now, where exactly did that insect land…?

The cost of materials for this small boat was around £250, including rollers, paint trays and tack-rags, and if the gloss lasts for the five to seven years as claimed, that's not a bad investment

9 tips and tricks for using sealants

Premium bonding: PBO's Ben Meakins outlines some techniques for getting the most out of sealant without ending up covered in the sticky stuff

You can't call yourself a practical boat owner until you've had at least one traumatic experience with super-sticky sealant. After our less than joyful time cleaning sealant from the windows of the PBO Project Boat *Hantu Biru* (PBO July 2013), we paid a visit to Sika's headquarters in Welwyn Garden City, where Gareth Ross showed us his tricks and tips for getting the best from sealants. He was dressed in a shirt and trousers, but stayed amazingly sealant-free: proof that you don't have to end up wearing more of the stuff than the boat.

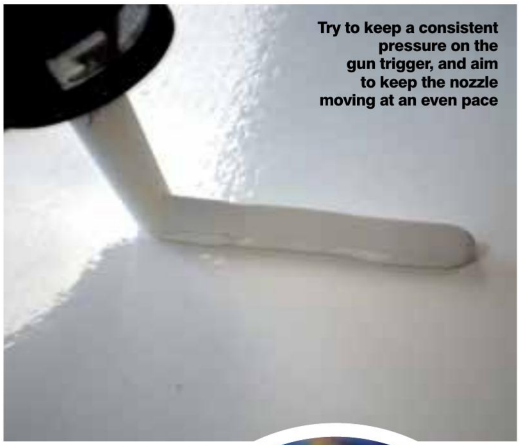
Primers can make a big difference to a sealant's ability to stick to a surface

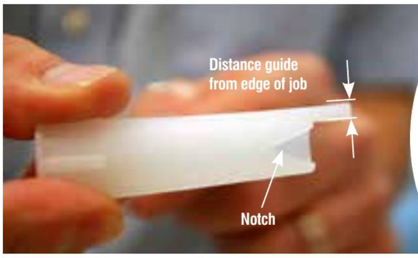
1 Use a primer wherever possible

Primers help sealants adhere to the chosen surface. They have a short shelf life, but improve adhesion by around 20%. Some solvent-based primers can be applied by cloth, but most should be brushed on.

2 Aim for a triangular bonding bead

By and large, if you are looking to bond something on, it's best to use a triangular bead of sealant. This ensures the minimum amount of wastage, and an even bead when it's all tightened up. To get a triangular bead, cut a notch in one side of a nozzle and apply it with the gun perpendicular to the surface. You can also cut in a guide to keep the nozzle a set distance from the edge of the material being bonded.


Try to keep a consistent pressure on the gun trigger, and aim to keep the nozzle moving at an even pace



ABOVE A notched and cut-away nozzle make it easier to achieve an even bead of sealant
RIGHT A triangular bead flattens evenly under pressure

Sealant will start going off as soon as you open it, so don't leave a tube hanging around without a full nozzle

3 Sealant shelf life once opened

Most sealants cure at the rate of 2-3mm per 24 hours, which is why it won't last forever in its tube. It is moisture-cured, which means that in hot and humid conditions it'll go off even more quickly. Keeping it in the fridge will slow the rate of cure somewhat. Always keep the nozzle attached: the sealant in it will cure slowly but can often be pulled out to reveal fresh sealant at the start of the tube. For obvious reasons, don't open a tube until you're ready to use it.

There's no miracle chemical to remove sealant – it usually has to be cut or scraped away

4 How to remove sealant

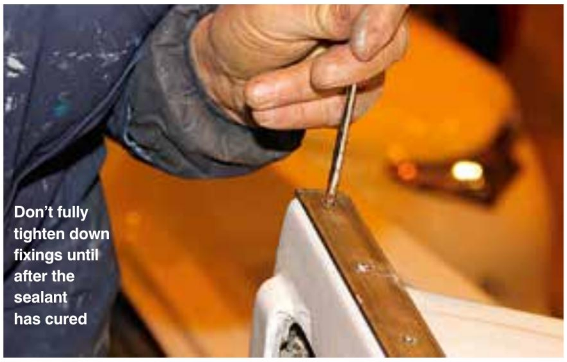
Sealant manufacturers are often asked if there is a miracle chemical that will remove their sealant: the short answer is usually 'No!' The only way to remove cured and well-adhered adhesive sealant is with mechanical methods – ie a sharp knife, vibra-saw, cheese wire – or abrading it off with a sander. Here Gareth is removing Sikaflex from a window frame by gripping it with needle-nosed pliers and cutting it away with a scalpel.

6 Spray to aid curing

As already mentioned, polyurethane sealants are moisture-cured. You may find when bonding large swathes of a teak deck to glassfibre or steel that the sealant may struggle to find enough moisture to begin curing. To give it a helping hand, use a spray bottle to spray a very fine mist over the laid deck to kick-start the curing process.

Sealing deck fittings 5

When sealing deck fittings, screw or bolt them down almost tight then wait for the sealant to cure before giving the fixings a final tighten to compress the sealant and bed them down as securely as possible.



Don't fully tighten down fixings until after the sealant has cured

LEFT Raised caulking can be left to cure and cut away later

BELOW Don't smooth too much as to leave hollow caulking (we haven't masked this test piece)

7 Caulking wood-planked decks

There are two main ways to caulk the seams of a teak or other wooden deck. One is to overfill the seams between the planks, leaving the sealant to stand proud until it has cured. You can then cut away the excess with careful use of a sharp chisel, followed up by sanding.

The second option is much more labour-intensive, but results in less wastage of sealant and less sanding overall. You'll need to mask off each joint so that the surrounding teak is covered, before applying the sealant. Smooth the sealant off with a scraper before it cures, being careful not to smooth away so much that it leaves a hollow, then carefully peel off the masking tape, also before the sealant fully cures. Peeling the tape is messy, but there's much less sanding to do afterwards and no risk of accidently chiselling gouges in your lovely new deck.

Some boatyards claim the first option is best. They won't remove the raised sealant until near the end of the job – walking on the raised surface is a great way to protect the teak during work.

8 Applying bedding compound

Bedding compounds such as Sika 298 are surprisingly quick and easy to apply. Simply snip off the end off the 'sausage' before squeezing the gloop onto the deck and spreading it out with a notched spreader to ensure an even layer of sealant.

LEFT Lay bedding compounds with a notched spreader

9 Get a good gun!

If you've got a lot of sealant to apply, it's well worth getting a good-quality ratchet or electric-driven gun. Your hand muscles will start to hurt surprisingly quickly with a cheap gun – especially with window adhesives which can be stubborn to squeeze out of their tube. PBO

Achieving an even bead is easier with a good-quality sealant gun

Gelcoat polishing

You can get a good shine on even heavily faded gelcoat with a bit of elbow grease...

Modern GRP hulls are impressive: they put up with a lot of abuse and require very little maintenance to keep them in good order. Most people will plan to 'polish' their hulls in the spring before the boat goes back in the water – but what does that really entail?

The problem is that gelcoat becomes chalky and hazy over time due to the unfriendly conditions that are present in the marine environment – strong sunlight and salt water, plus chafe and damage from moorings, ropes and fenders. The main culprits are oxidisation and ultraviolet (UV) light damage. Gelcoat is a polyester resin, and as oxygen reacts with polymers in the resin it weakens their structure. UV light accelerates this process, which in turn enables the degradation to work deeper into the gelcoat, causing a loss of gloss and pigment discolouration. Gelcoat also becomes increasingly porous as it gets older and attracts more stains from water and air, requiring incrementally more effort to bring it back to a good shine.

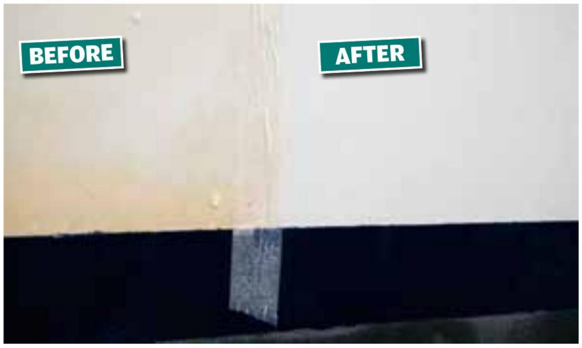
Transforming a hull from a chalky, oxidised state to a shiny surface to be proud of is really broken down into three phases: Cleaning, polishing and waxing.

Star brite
BOAT WASH IN A BOTTLE

1. Cleaning

The first step, and one that's often overlooked, is to clean the hull before you start any polishing. Hosing the boat down and using a detergent like Star Brite's Boat Wash In A Bottle will remove dirt and grime that could lead to the hull being scratched and damaged if it was ground in during the polishing stage.

With this done, take a look at the hull. Now is the time to remove any staining. Gelcoat becomes porous over time and can develop a yellow stain along the waterline. While it's possible to remove this with polish, the gelcoat will last much longer if you use an oxalic acid-based cleaner, such as Y10 or Grunt boat cleaner. This requires little more effort than painting on with a brush and rinsing off a few minutes later, leaving the hull sparkling white in the process.



A badly oxidised hull, before (left) and after (right) treatment with an oxalic acid cleaner

With the hull clean and free from staining, give it a rinse with fresh water and dry it off. If you're in a hurry, a squeegee as used by window cleaners will remove water from the large flat surfaces much quicker than any other method.

2. Polishing

Next comes the first polishing stage. With the hull clean and dry, take a look at the condition of the gelcoat. If it looks reasonably shiny, you can probably get away with a wax – but if there is any oxidation or any chalky areas of the hull, you'll need to 'cut back' the gelcoat to restore its colour and shine.

Rubbing compounds are available in various grades: this one, Farécla G3, is suitable for lightly oxidised hulls

For this you'll need a rubbing compound, or something slightly abrasive. Colour restorers are usually abrasive, with compound mixed in the liquid. This literally 'cuts back' the top surface of the gelcoat to reveal an un-oxidised layer beneath. If doing this by hand, work on small areas one at a time.

Some one-step cleaner-restorer-waxes are available which are excellent for time-poor boat owners, but for the best finish you should go for single-stage products.

Using a power polisher

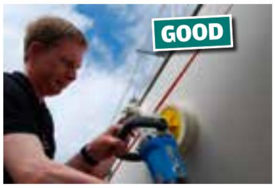
Hiring, buying or borrowing a power polisher is a wise choice. But using a heavy machine above your head can be tiring, and an incorrect technique could have disastrous results for your gelcoat.

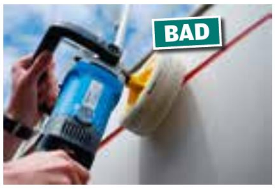
Here's how to do it properly.

- Firstly, choose the best machine you can afford. Make sure it's a slow-revving polisher – never use an angle grinder or orbital sander with buffing head as these run at far too high an rpm for your gelcoat.
- Work slowly and take regular breaks.
- Apply small amounts of polishing compound at a time.
- Use a cloth to smear it on the area of the hull you're working on, but don't apply too much – you don't want it to dry out before you get polishing.

- Keep the buffing head damp to avoid heat build-up – a spray bottle of water is ideal for this.

- Some products come in a squeezy bottle – and for these, apply them to the buffing head on the polishing machine, and use this (with the machine off) to transfer it to the hull in a figure-of-eight motion.





- With the rubbing compound distributed, gently hold the pad against the hull and start the polisher. Keep the machine within your shoulder width if possible, and try to hold it so that the flat pad sits comfortably against the hull. This can be hard to do until you've developed a technique, with the machine wanting to skid off one way or another – but keeping the head flat to the hull will help.
- Keep the machine moving all the time, as staying on one spot can lead to overheating.
- Keep the speed of the polisher nice and low. Ideally, you should keep it at between 1,000 and 1,500rpm to avoid burning the gelcoat with a build-up of heat. Also, avoid pressing too hard. Remember that all you need to do is remove a tiny layer of gelcoat to bring the shine back, so don't go too crazy. You can always go back and take more off – but the opposite is not true!

Mind the edges

At chines, transom edges and on the edges of mouldings, it's very easy to apply too much pressure and rub through the gelcoat. It might be best to use the machine on large flat surfaces and then cut back edges, corners and tricky areas like coamings and cabin sides by hand, just to be sure.

Cleaning up

When done, you can wash out buffing heads and polishing pads in water. If you don't do this, the hardened paste can scratch the gelcoat next time around.

3. Waxing

With the oxidation removed and the hull good, clean and sparkling, don't be tempted to launch yet! Your hard work could be spoiled if you don't seal the surface with a wax. This has two functions – it provides a protective layer and also acts as a sunscreen, with UV protectors preventing oxidation and fading.

Apply the wax, allow to dry to a haze

...and wax off with a soft, dry rag

These are as simple as wax on, wax off – applying with one cloth and polishing to a good shine with another. If you've done the hard work with a polisher at the cutting stage, there's probably no need to use a polisher for the waxing step – but it's up to you. Apply the wax in small areas one at a time, using circular motions. Apply it, wait until it's dried to a hazy finish and then polish it off with a soft cloth.

The shine is restored after cleaning, polishing and waxing the gelcoat

Cleaning coloured hulls

Coloured hulls look great – but need more work to keep them looking good. However, as long as the gelcoat isn't too badly damaged you can restore them easily, starting with wet-and-dry sandpaper, used wet.

This She 31 was badly oxidised, and the blue hull looked faded and sad. It was reconditioned by the team at Yachting Sports UK, in the following way.

To recondition the faded gelcoat, they started with abrasive paper. It is important that wet-and-dry sandpaper is used, and used wet. Start with paper around 600-grade – this should bring the original colour back. After this you'll need to work up through grades 800 and 1,000. Take care not to sand through the gelcoat, especially on radiused corners. The amount you can sand the surface depends on the thickness of the gelcoat.

Next they used a fine rubbing compound (Farécla 500), followed by a polish (AutoGlym). This brought the surface back to a good shine.

For areas where light scratches are present (a light scratch is one that has not penetrated the gelcoat) it is possible to sand them out again with wet abrasive paper, usually no coarser than 320-grade. However, care should be taken not to break through the gelcoat.

If a gelcoat repair has to be carried out it is best to refinish the surrounding surface first so that you match the original colour, not the faded one.

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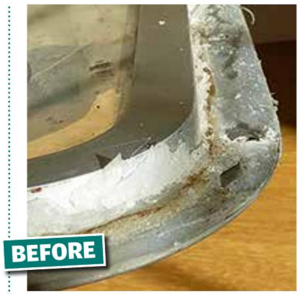
Renovating boat windows

Stephen Wallace demonstrates how he went about removing, resealing and reinstalling the windows on his 25-year-old Sadler 32

Seal of approval: the resealed, leak-free windows



The butyl sealant had irrevocably broken down

Leaking windows, drips and dampness are not fun on a boat: children complain, 'other-halves' become potentially mutinous and life becomes generally unpleasant every time it rains. Dampness pervades, and token attempts to put off the inevitable eventually expire in their effectiveness. Having tried silicone sealant, Captain Tolley's and other alchemistic remedies, the plain facts become clear: the butyl sealant has irreparably broken down, and it's time to reseal the windows properly.

Our Sadler 32 is now 25 years old. Having initially tried quick fixes, we found that they may buy you a season or two, but resealing the glass and re-bedding the frame is the only real answer. When we eventually cleaned out the frames prior to resealing the glazing, we found the old butyl to be completely shot, ranging in texture from mainly flexible rubber at the top of the window to hard black and porous Crunchie-bar texture at the bottom.

Good value

We've now discovered the considerable length of time it takes to remove, disassemble and clean the frames and glass, insert the glazing butyl with sufficient pressure and finish/cure them – all in all, about 10 days. I'd heard good reports about Eagle Boat Windows, so I contacted them for advice on materials and details of how to do the work properly.

(Their alternative service of professional resealing on behalf of owners is extremely time- and cost-effective, enabling you to concentrate on the removal and reinstallation of the windows.) We ordered a kit from Eagle which included glazing primer and 2kg of two-pack butyl glazing sealant, two tubes of Arbomast BR butyl sealant to bed the frames, gloves, rubber chocking for the glass, scourer pads and a small plastic tool – all for just over £80 including p&p, which seemed good value.

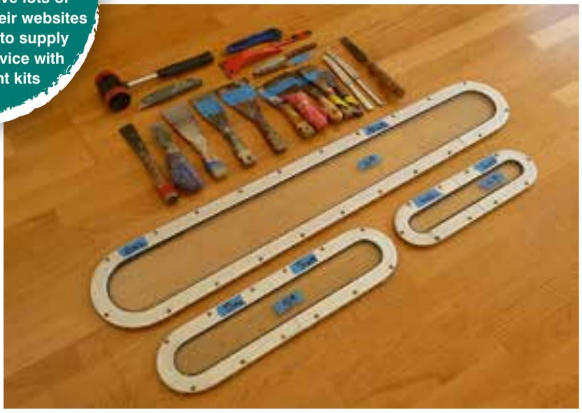
TOP TIP

Boat window refurbishers (eg www.eagleboatwindows.co.uk) often have lots of information on their websites and are happy to supply further info/advice with their sealant kits

▼ TOOLS FOR THE JOB

ARBOMAST BR
BUTYL BASED SEALING COMPOUND
ARBOMAST BR
BUTYL BASED SEALING COMPOUND

The Eagle Windows kit (gloves and chocking rubber not shown)



The removed windows, and the tools used in their removal

Removing window frames from the boat

The window frames on our Sadler 32 were very well stuck in with silicone, so our somewhat painful experience removing them may be a great deal less arduous for you if you decide to tackle the same job

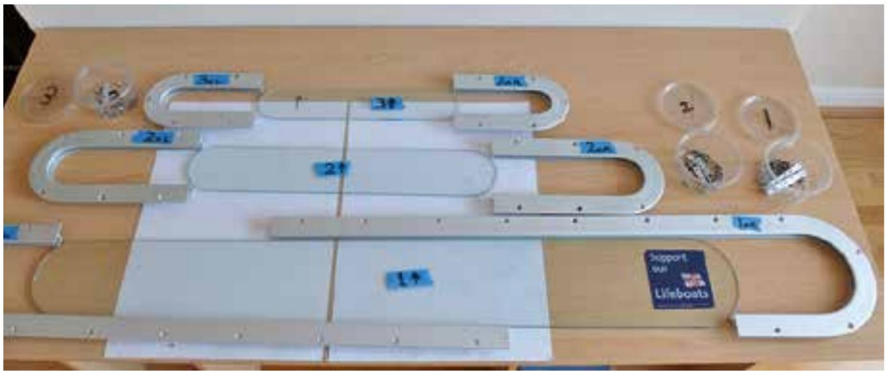
You'll need a screwdriver, lots of stripping/filler knives with good spring steel (enabling them to bend), sharp Stanley knife blades/similar craft knives, blue (14-day) masking tape and some duct tape.

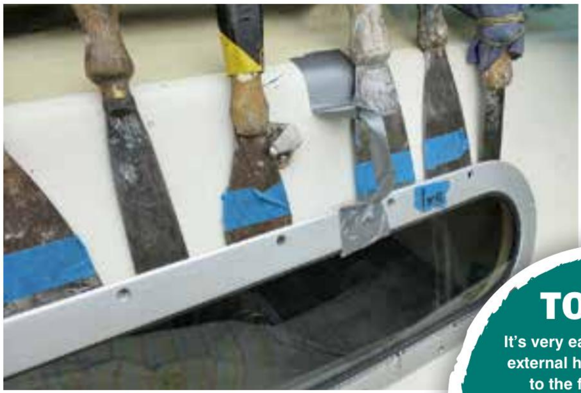
On the outside of the boat, use blue masking tape to individually mark each frame component and glazing pane with the window number, orientation and whether it's left or right (ie 6L↑). It seems obvious, but when everything comes apart this is all you'll have available to ensure accurate reassembly.

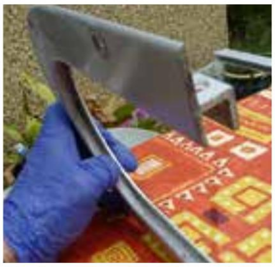
Our window frame section is a small 'h', with the upright of the 'h' forming the flange against the boat – this is normally the only part bonding the frame to the boat. Unfortunately ours had been bedded both on the flange and also the 'reveal' return into the boat, against internal GRP surround mouldings. To make matters worse, the bedding was silicone rather than butyl sealant, making the frames seemingly impossible to shift.

The good news was that the frames were held in by self-tapping screws rather than inter-screws, so as they were removed they went into individually-labelled clean hummus pots, as did later components.

To remove the frame I first carefully cut the silicone sealant internally with sharp blades at the window/GRP frame moulding interface, some areas being too tight to reach at this stage. Then I went around the exterior of the frame edge with both narrow and wide stripping/filler knives, progressively cutting into the silicone. Initially this cut was to a very shallow perimeter depth, but became progressively deeper as I worked around the frame.


The frame components individually marked up with masking tape, which will stick when wet


Several scrapers were used in tandem and leapfrogged around the frame

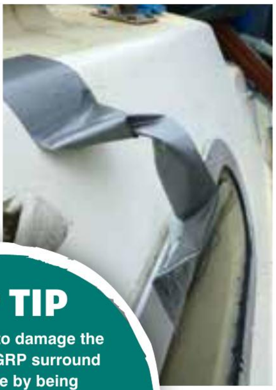

The 'h' section of the window frame

The process is basically one of attrition, alternately cutting around the frame from inside and then outside. There comes a point when you can get the stripping knife into a gap and, using a light mallet, can carefully cut all the way through to the frame, progressing all around. Greater speed can be achieved by leapfrogging the most effective filler knives (often narrow and thin-bladed) and leaving several others in their place progressively around the frame perimeter, gently breaking the seal with the hull.

Self-tapping screws and frame holes need cleaning too

By rigging up a couple of 200mm pieces of duct tape outside the boat in a small loop from hull to window frame I was able to increasingly move the window frame, but avoided a nasty crash when the windows eventually popped out after gently pressing the frame from inside the boat!

The boat hull can be made watertight by using polythene sheet held in place by duct tape, which is messy to remove, or blue masking tape (which is better) to create temporary glazing. If you're doing the work at home, take some old dust sheets to wrap the frames in for safe transportation.


A duct tape 'loop' saved a resounding crash as the window popped out!

TOP TIP

It's very easy to damage the external hull GRP surround to the frame by being overenthusiastic with the filler knives. Use a couple of pieces of masking tape on the knife itself about 2cm back from the blade edge, or mask the hull with tape to act as a sacrificial layer.

In terms of time taken, our first batch of three windows on the port side took a day, and a lot of sweat, to remove. The silicone was tenacious, and at times I wondered whether the frames would come out at all. This experience enabled the second batch of three to be removed in about five hours, so overall you could say frame removal is a two-day job. Yours will hopefully come out a lot more easily if they have butyl frame sealant and are not stuck on the 'reveal' as ours were.

Dismantling and cleaning window frames

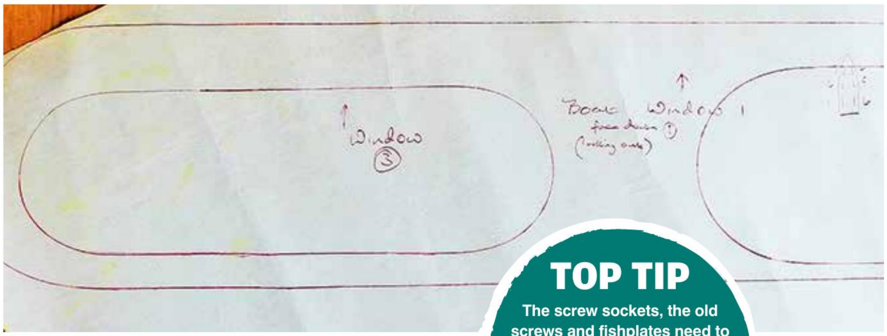
Make sure you have screwdrivers, plastic scrapers, gloves, snipe-nosed pliers, blades, a butyl kit, a suitably prepared work surface, hot soapy water, white spirit and a piece of wallpaper to hand!

Before dismantling anything, lay all frames face-down on a piece of wallpaper and stencil around them. Mark the stencil with orientation and window number. Note the difference in width between the stencil line and the frame itself.

When you eventually reassemble them you will then have an accurate guide to the original width, enabling any necessary light clamping to realign them while the butyl is fresh, ensuring accurate alignment of screw holes when mounting back onto the hull. This is particularly important for larger frames.

For the next stage you'll need screwdrivers, plastic scrapers, gloves, snipe-nosed pliers, blades, butyl kit and work surface protection. White spirit and meths now became our best friend: they are very effective. White spirit and paraffin will not dissolve cured silicone, but once most of the sealant has been removed with a blade they will soften the remaining residue, making it more susceptible to removal with a blade/plastic scraper.

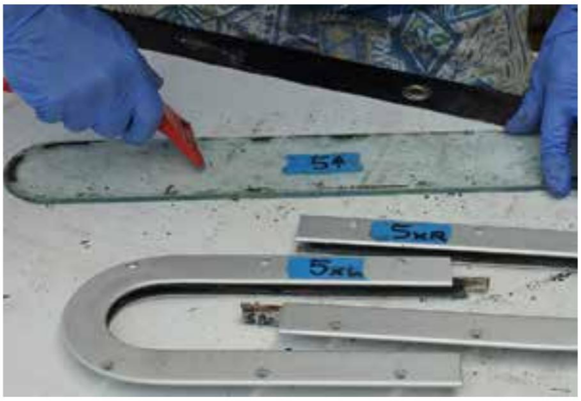
With the frames now free of the boat, the real work began: cleaning and disassembling them prior to resealing the glazing. Our aim was to ensure all surfaces were clean and free of oil/silicone so that the primer and butyl sealant could bond properly to both frame and glass. Cut into the butyl all around the frame perimeter on both sides with a new Stanley knife blade. The butyl may be very hard, so white spirit can help soften it. Do this several times to full depth so the glass is released from the frame.



Stencilling the frames with orientation and frame number

Cutting into the old butyl with a sharp blade

Our channelled frames were in two halves held together by fishplates – thin strips of metal located in the bed of the channel held by screws through the frame. These need to be released to get the frame apart. After mounting the frames in a workbench, the fishplate screws need to be removed from at least one side – not necessarily easy as a result of the unholy marriage of stainless steel screws and aluminium frames!



Cleaning the glass and edge using hot soapy water, white spirit and Cif

Take care not to damage the anodising, distort the frame or break the glass when clamping, so use an old cloth for protection. Carefully clamping the frame enables you to get real pressure and turning force on the screwdriver without the head jumping. Pre-treatment with penetrating oil and hot water may help to dissolve the salt/oxide build-up and expand the aluminium.

Next we separate the two frame halves. Clamp just one end of the frame, so the other end is free to move. Wrap a piece of strong, thin material (eg polyester) around the end of a preferably rounded filler knife, then insert this between the frame and glass at the end of the frame. Using a mallet, gently knock the two halves apart, taking care not to distort anything.

TOP TIP

The screw sockets, the old screws and fishplates need to be clean and salt/silicone-free to create a leak-free seal when reassembling. Hot soapy water followed by gentle abrasion can be used to clean these.

Separating the frame halves which were held together by fishplates

To clean out the frame channel use an old, long, narrow screwdriver to dig out the old butyl, then plastic scrapers and finally a Scotchbrite pad together with plenty of white spirit. Clean the glass and its edges. As our frame progressively became cleaner I used a combination of washing in hot soapy water, Cif, white spirit and finally meths to ensure a clean surface. I also tried using a chemical that is supposed to dissolve cured silicone, but in my experience it was either totally ineffective or had an effect of about 1 out of 10.

The hull window opening needs to be as clean as the window frames, so I used a variety of tools and several home-made perspex scrapers (which proved invaluable as they didn't scratch) in conjunction with white spirit and Cif.

Resealing the glazing into the frames

Starting now with chemically clean frames and windows, it's time to start reassembling everything. Drawing a quick 'chocking' diagram for each frame may well prove invaluable as a reference source

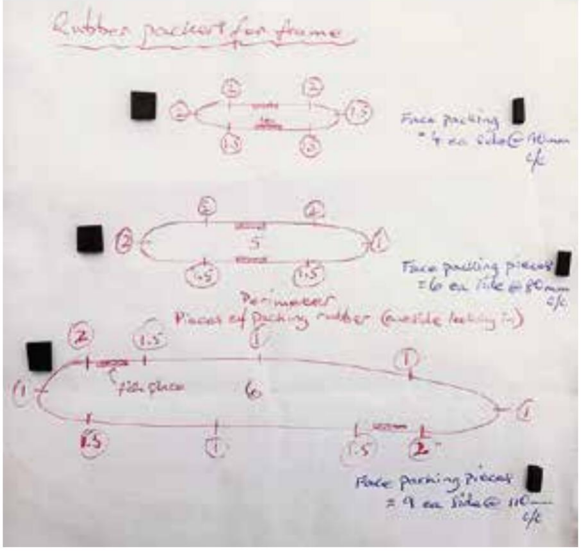
As a dry-run, first reassemble the glass into the frames with the fishplates fixed on one side only, and determine how much channel-chocking rubber is needed by inserting it into the frame channel base around the glass perimeter to provide about 1-2mm of movement of the glass within the frame. This may take several attempts, and is likely to involve either single or double thicknesses of rubber: ensure they are cut generously to hold themselves tightly in place.

For the channel-base perimeter chocking rubber, cut the rubber strip into 8-10mm-wide blocks the (tight) width of the channel and about 1cm long, using a caliper depth gauge as a template guide to ensure lengths are accurate. Fit to the frame as necessary. Check against your stencil of the original frame size and make sure any cramping leaves some movement.

Try to ensure the glass is central and clear of the fishplates. I drew a quick 'chocking' diagram for each frame, which proved a useful reference when one or two of the earlier frame chocks dropped out during handling before application of the butyl. When satisfied with the fit, do a final assembly by putting some butyl sealant bedding compound onto the cleaned fishplates and mitre joints then screwing together. The frame can be left overnight, then cleaned up with a blade dipped in white spirit.

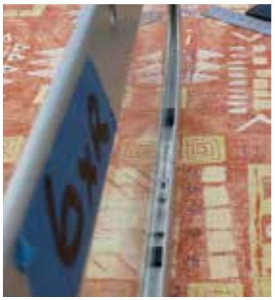
A fishplate covered in sealant, prior to assembling a frame

Pressing the glass down created a new void all around the frame


Rubber packers for frame
Face packing = 4 ea side @ 90mm c/c
5
Face packing pieces = 6 ea side @ 80mm c/c
Perimeter Pieces of packing rubber (outside looking in)
fish plate
6
Face packing pieces = 9 ea side @ 110mm c/c

We drew a rubber chocking piece diagram for the glass and frames

Cutting the chocking rubbers



The chocking rubbers in place in the base of the channel

For the internal glass face chocking rubber, cut short lengths of rubber about 5mm wide and the depth of the channel less about 4-5mm, so when the glass is inserted it will be supported in its internal vertical face but have sufficient 'cover' of butyl glazing sealant. I added the number of chocks per side and spacing to the chocking diagram: a useful guide later when inserting the butyl.

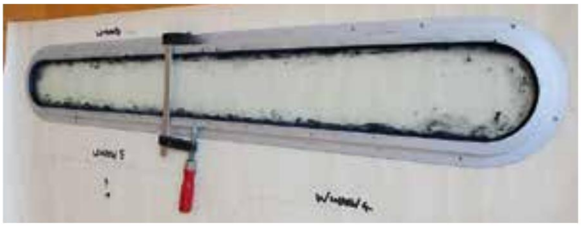
Use a small (say ½in) brush to apply primer to the inside and outside faces of the frame/glass interface, then set aside for over 30 minutes (but less than 8 hours) prior to filling the frame with two-pack butyl. This butyl has one black and one white component, in our case 1kg each. The white is like a dryish putty and can be cut easily, but the black component is rubbery and deforms before it cuts. I therefore found it easier to measure these by weight before mixing. Wearing gloves, mix these stiff components in equal quantities by twisting and kneading until the marbling becomes a consistent black colour: no need to rush, it cures in days rather than hours.

Lay the frame down with the outside face up and firmly insert the butyl into the frame, using a strong rotating action to maximise pressure until it can be seen filling the bottom channel of the frame. Clean off the excess. Turn the frame over, face down, and carefully press the glass down to create a new void all around the frame into which the internal vertical face chocking rubber is inserted at intervals of roughly 75-125mm. These are pressed in below the frame edge but still support the glass: make sure they don't rotate by using a flat rather than rounded pushing tool.

If you have done the 'face-up' butyl filling properly these will bed into the butyl at the bottom of the channel. Now force butyl into this side, working around the frame and taking care not to create voids, then chamfer/radius the edges to lap the frame using any convenient tool or knife (clean-up is done some days later). Turn the frame over and chamfer/radius the face-side butyl. While the butyl is fresh, check the frame dimensions against the stencil of the original frame and cramp if necessary. Set the frames to cure, undisturbed, in a warm place for at least a week before cleaning with a soft cloth

Filling the face side with two-pack butyl, using a strong rotating action

Smoothing a radius into the butyl edges with a knife



The frame was cramped to the original dimensions on the stencil

Bedding the refurbished frames back into the boat

Finally, the frames are re-bedded back into the boat hull. We prepared each frame for installation using one-pack butyl sealant, which is essentially non-setting and can be cleaned up easily with white spirit

First, check the fit of the window and alignment of screw holes in the hull opening: thankfully all our screw holes lined up correctly.

Despite our careful stencilling, some of the hull window openings still needed a couple of mm of easing to enable the frames to fit back in. I therefore made a small tool to hold abrasive sheet from a 10cm block of wood and some old aluminium tile trim, which happened to be the same depth as the frame. Any additional making-good of the opening was also carried out at this stage.

Our windows have a slight curvature, which immediately straightens when you remove the frame from the boat. There is therefore a tendency for the central section to be compressed, squeezing out any sealant and potentially giving rise to future leaks. This didn't seem an attractive proposition after all the hard work, so to avoid this I decided to incorporate small rubber spacers made of some Firestone EPDM roofing material I had been given. It was just over 1mm thick and was bedded in the same butyl sealant a day in advance of installation. Note that this is a non-standard procedure: however, reading the PBO forum, some other people feel spacers are desirable.

Each frame was prepared for installation using Arbomast BR (one-pack) butyl sealant. This versatile material is intended for 'covered' sealing applications and is essentially non-setting, apart from an external skin which forms to a stiff chewing-gum-like consistency after a day or so. It cleans up easily with white spirit.

Cut the butyl nozzle at 45° and apply a 6mm bead of bedding compound on the inside of the window flange in line with the screw holes, forming a doughnut shape around the screw holes themselves. Use a little more if incorporating spacers.

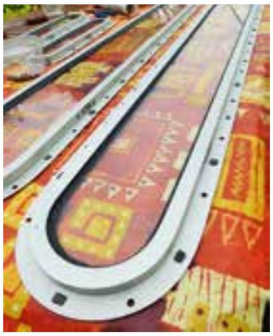
Present the window to the hull the right way up and gently press it against the hull, which will create a 'witness' around the perimeter. Remove any initial sealant appearing in screw holes in the frame before the screws are inserted, otherwise a hydraulic build-up of pressure in blind-ended holes or inter-screws can occur. However, you may also wish to put a little sealant around the neck of the screw to ensure an effective seal. Carefully tighten the screws, working around the perimeter of the frame, doing this in rotation several times until only a small gap remains between hull and frame. The butyl should not be squeezed out completely or it will leak. Screws should only be 'nipped up', not fully tightened. Leave for a few days to harden, then trim using a scraper and white spirit.

So that's that job complete. It took longer than expected, but will hopefully mean we're watertight for another 25 years.

The frames were inserted to check fit and hole alignment

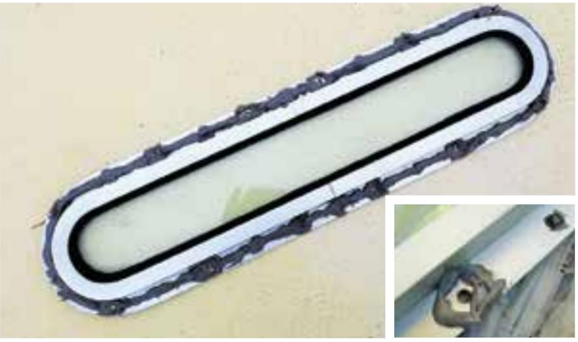
An 'easing' tool, about 10cm long, adjusted the hull window aperture

and white spirit.



Thin EPDM sheet roofing packers (bedded in butyl) were used to avoid butyl sealant squeeze-out

One of the window frames, cleaned up and reinstalled



A 6-7mm sealant bead was applied in line with the screw holes, forming a doughnut shape around the holes themselves

LESSONS LEARNED

1 **Window refurbishment is a lengthy and labour-intensive job taking around 10 days (excluding curing time) for six windows: just cleaning the frames took two days.**

2 **Use a professional resealing company's services if time is tight; this then enables you to concentrate on removal/reinstallation.**

3 **The two types of butyl were pleasant but messy to work with – prepare!**

4 **Your technique will improve as you do more windows, so do the job in a couple of batches.**

5 **There's more to this job than meets the eye, but it's well within the capabilities of a practical boat owner!**

Finding the perfect paint

Nothing slows a boat like fouling on the hull. Here's how to choose the antifouling that's best for your boat and pocket

Choosing the right antifouling is one of the most crucial sailing decisions you will make all year. New sails, carefully tensioned rigging and vigilant balance and trim are worthless if beneath your boat resides a malevolent hybrid between a coral reef and the hanging gardens of Babylon. Even moderate fouling can easily lose you a knot or more of boat speed, slowing your cruising and destroying any chances you might have round the cans.

For this reason, racing sailors can frequently be seen scrubbing their hulls or even dry-sailing their boats to make sure that the hull is perfectly smooth and clean, but most cruisers prefer a lower-maintenance approach that will last all season. To achieve that aim requires careful research, careful application and sometimes a slice of luck.

Why antifoul?

Coastal waters are a rich organic soup containing a host of animal and vegetable organisms. Many of these are looking for somewhere to settle down and reproduce, and any underwater surface that will stay still long enough is fair game. Just take a look at the pontoon floats or piers at your local marina to get an idea of the rich panoply of marine life that we commonly class as 'fouling'.

Antifouling manufacturers break this group down into three simple classes: weed, slime and shell. They're fairly self-explanatory, but each has its own issues to solve.

How does it work?

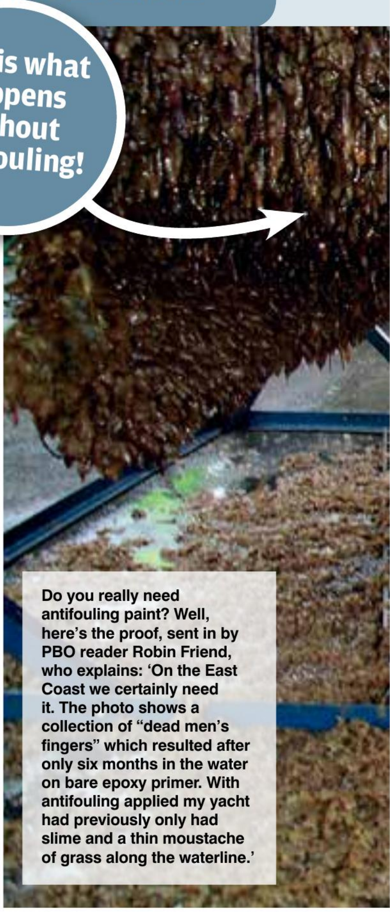
This article focuses on the use of paint to discourage fouling, but any antifouling system has three methods available to attempt to prevent marine growth.

The first is to try repelling growth by creating an environment which discourages it from attaching to the hull to begin with. Paints do this by continually leaching a biocide into the water to form a hostile climate immediately adjacent to the hull.

If fouling still attaches, the same biocides can sometimes repel the fouling by destroying its ability to hang onto the hull. However, some growths can tolerate them once established, shell fouling being a good example.

In some areas, notably Littlehampton, Oban and Largs, the balance of warmth and salinity is ideal for a phenomenon known as barnacle spat, where young barnacles in their millions seek somewhere to settle. These can attach to a hull before the antifouling paint has time to act and, once settled, can only be removed by scraping. In the worst cases, new antifouling has to be applied – luckily barnacle spat only occurs every five to 10 years!

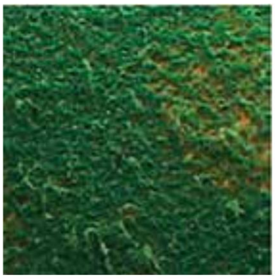
If the biocides fail, some antifouling has one more trick up its sleeve – it's either too slippery or too unstable for the fouling to get a good grip. This is sometimes achieved by using a low-friction surface such as Teflon (PTFE) or silicone, or more traditionally with a surface which will naturally erode, refreshing the surface regularly and shedding the top layer and its associated fouling organisms.



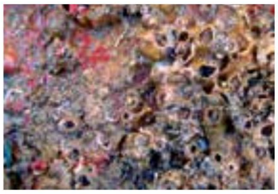
Do you really need antifouling paint? Well, here's the proof, sent in by PBO reader Robin Friend, who explains: 'On the East Coast we certainly need it. The photo shows a collection of "dead men's fingers" which resulted after only six months in the water on bare epoxy primer. With antifouling applied my yacht had previously only had slime and a thin moustache of grass along the waterline.'

TYPES OF FOULING

WEED: Although it looks the worst when hanging from your hull, weed is actually the easiest fouling to tackle with antifouling biocides. If it does take hold its grip is usually fairly weak, such that fast sailing or at most a basic scrub will remove it.



SLIME: This can include grass and sediment, and is a difficult type of fouling to combat as it can clog antifouling paint, reducing its effectiveness. Co-biocides can deter it, but if it takes hold scrubbing is the only answer, rapidly eroding the paint and reducing its life.



SHELL: The worst of the three, shell fouling gives a rough surface to the hull which seriously impacts boatspeed. Several animal growths contribute to this type of fouling, including barnacles, tubeworm and hydroids, the frond-like organisms you sometimes see amongst weed on hulls. Even after scraping, shell fouling can leave calciferous deposits which slow the boat and promote more fouling.

Which antifouling is best for your boat?

Broadly speaking, antifouling paints fall into two categories: eroding (self-polishing) and hard.

Eroding antifoulings are commonly used for cruising yachts and displacement powerboats which stay afloat throughout each tide. As these craft are fairly slow, the scrubbing action of water going past the hull is small, so the paint needs to discourage growth without the aid of significant waterflow. To do this, the paint dries in such a way that the biocides are distributed evenly through a resin matrix, which erodes over the course of the season so that fresh biocide is continually exposed to the water.

The biocide used is usually copper oxide, although for

aluminium hulls alternatives are available to avoid galvanic effects. An interesting point regarding the use of copper is that bright white antifoulings tend to be less effective than coloured paints, because the manufacturers are forced to use a lower copper oxide concentration or a different biocide to preserve the colour – for this reason many white antifoulings are actually off-white.

Manufacturers frequently add co-biocides to their antifoulings, such as Zineb (Preventol A4S) or Zinc Pyrithione (ZPT), incidentally one of the active ingredients in anti-dandruff shampoo. These are claimed to be more effective against certain types of fouling, allowing a lower concentration of copper oxide and improving the paint's efficiency against a broader range of fouling organisms.

In general, antifouling performance increases with price, as the high-performance antifoulings tend to include higher concentrations of biocides and better release resins. High-performance antifoulings can also sometimes buy better speed for your boat – International Paint say that their Micron Optima product self-smooths, with erosion by seawater causing it to become so smooth and slippery that they even say it can be used for racing. However, there are situations where spending more may not be the answer. Hempel point out that for areas where slime is a problem, it can be worth changing to a lower-performance product which erodes more quickly in order to shed the slime layer (in their case, Tiger Xtra to Cruising Performer).

Hard antifoulings are favoured by racing yachts, performance powerboats and by cruising yachts on drying moorings. The latter case is simply because regular contact with the seabed can abrade eroding antifouling away, while for performance powerboats an eroding antifouling will erode too quickly at high speed. For racing yachts the advantages are more subtle. A hard antifouling can provide a more even surface than an eroding paint, which is good for boat speed, but ideally this smooth surface should be burnished – abraded back with wet or dry paper. This not only makes the finish smoother still, but also helps release fresh biocides.

There is one other type of antifouling commonly available, which is effectively a subset of hard antifoulings. These provide an exceptionally smooth surface which is easily scrubbed clean without the need for abrasion, such as International's VC Offshore with Teflon or Hempel's Glidespeed. Many companies are also experimenting with nano-particles, where the particles which form the surface of the paint are designed to be so tiny that fouling organisms cannot get a grip between them.

THE FUTURE OF ANTIFOULING

For the moment, biocides are here to stay. European legislation is tight and antifouling manufacturers must register and check each biocide and the concentration they plan to use with the governing body.

Biocidal antifoulings are becoming ever more high-tech, especially the eroding products. Manufacturers are designing the resin binders which hold the biocide to erode in a very controlled and predictable manner, such that the exact amount of antifouling required for a season can be predicted and applied in the right areas.

For example, International Paint have a product available for superyachts, Micron 66, which they describe as a 'true' self-polishing antifouling owing to its ability to erode in static water.

Based on the skipper's prediction for how much time will be spent sailing or in port, International will calculate the exact amount of antifouling they need to apply between dry-docking, specifying the thickness in microns rather than the number of coats.

These kind of products are perhaps an indicator of the way boat owners will need to think in future to make the most of new, high-tech paints. The advantages: better performance in both moving and static water, more controlled biocide release and such a thin coat remaining at the end of the season that surface preparation for next year is minimal.

However, there is always a risk that further controls will be placed on the use of marine biocides, so manufacturers are considering how they should react. Their answer, almost without dissent, is silicone-based antifouling.

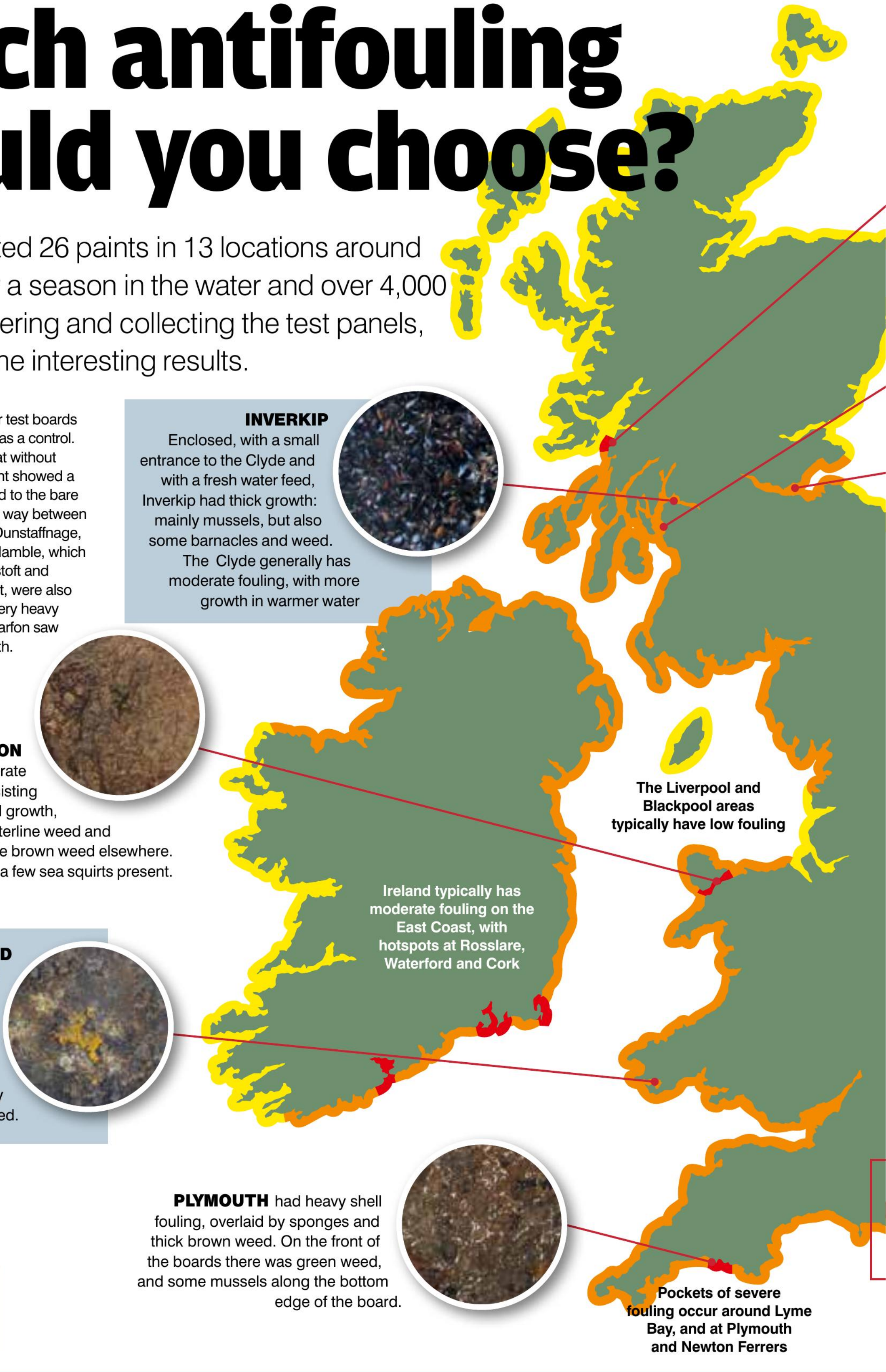
Silicone provides a surface to which very little can gain hold, and is already being used on commercial shipping to good effect. It entirely eliminates the need for biocides, but at present holds two problems for leisure sailors: the products usually need professional application, and they typically rely on the boat travelling at speeds greater than eight knots to dislodge the fouling.

This technology, or at least one working on a similar principle, is likely to be the future choice of most paint manufacturers. International Paint and Hempel have their respective Intersleek and Hempasil products on commercial ships, while Seajet already offer a silicone product for leisure craft: Seajet Speed.

Which antifouling should you choose?

In 2015 PBO tested 26 paints in 13 locations around the country. After a season in the water and over 4,000 miles spent delivering and collecting the test panels, we collected some interesting results.

We left the backs of our test boards as bare primer to act as a control. The good news is that without exception, every antifouling paint showed a marked improvement compared to the bare panels. Fouling differed in a big way between each of our 13 locations, from Dunstaffnage, which had minimal growth, to Hamble, which showed by far the worst. Lowestoft and Waldringfield, on the East Coast, were also bad. Whitby and Inverkip had very heavy slime, while Neyland and Caernarfon saw moderate shell and weed growth.



INVERKIP
Enclosed, with a small entrance to the Clyde and with a fresh water feed, Inverkip had thick growth: mainly mussels, but also some barnacles and weed.
The Clyde generally has moderate fouling, with more growth in warmer water

CAERNARFON had moderate fouling, consisting of light shell growth, green waterline weed and moderate brown weed elsewhere. There were a few sea squirts present.

NEYLAND
Neyland, situated at the mouth of a river with some freshwater flow, had a base layer of barnacles, with some sea squirts, sponges and heavy brown weed.

PLYMOUTH had heavy shell fouling, overlaid by sponges and thick brown weed. On the front of the boards there was green weed, and some mussels along the bottom edge of the board.

The Liverpool and Blackpool areas typically have low fouling

Ireland typically has moderate fouling on the East Coast, with hotspots at Rosslare, Waterford and Cork

Pockets of severe fouling occur around Lyme Bay, and at Plymouth and Newton Ferrers

KEY

High fouling 🟥
Moderate fouling 🟧
Low fouling 🟨

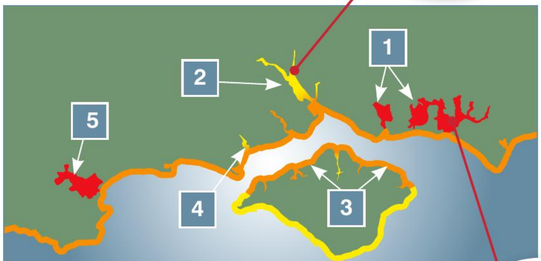
DUNSTAFFNAGE
Dunstaffnage, located near Oban, was our northernmost location, and had by far the lightest fouling. There were some small barnacles, minimal brown weed and very little slime. There was light green weed along the waterline.

RHU The fouling at Rhu consisted of heavy shell growth, with barnacles and worm casings, and brown weed, sea squirts and mussels lower down. There were crabs and some baby eels living in the weed.

PORT EDGAR The fouling at Port Edgar was moderate, with barnacle growth, weed and some sponges colonising the unprotected boards.

WHITBY The fouling at Whitby, a fast-flowing river, was mainly heavy, muddy slime. There was an even covering of small barnacles, with brown weed growth amid them. The bulk of the slime washed off relatively easily with movement.

HAMBLE The Hamble had the worst fouling of all the locations, despite the boards being located in fast-flowing water. There were fewer barnacles here, but sea squirts, brown weed, heavy slime and kelp had colonised the boards.



1 **Portsmouth and Langstone harbours can experience significant fouling**

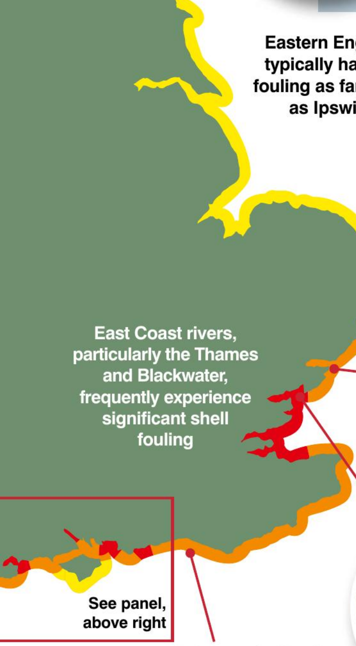
2 **Southampton Water is a low-fouling area, although there is a tubeworm hotspot at Shamrock Quay**

3 **The northern coast of the Isle of Wight typically has moderate fouling, although berths high up the Medina river can have low fouling**

4 **Lymington experiences variable fouling, reducing as you go upriver**

CHICHESTER
Chichester had particularly heavy fouling, with an underlayer of shell growth and barnacles, overlaid with brown weed, sponges and sea squirts. A few mussels clung onto the edges of the boards. Green weed grew at the waterline.

5 **Poole Harbour has a range of fouling conditions, but can experience heavy weed and slime growth, with moderate shell fouling**



Eastern England typically has low fouling as far south as Ipswich

East Coast rivers, particularly the Thames and Blackwater, frequently experience significant shell fouling

See panel, above right

Brighton fouling is usually moderate, but pockets can develop

LOWESTOFT had probably the most unpleasant fouling of all the locations, consisting of barnacles, sea squirts, sponges and some wriggling red shrimp.

WALDRINGFIELD
was among the worst-fouled places in this test. It had significant barnacle growth, covered in thick slime and brown, stringy weed. There was a heavy crop of mussels with a few sea squirts.

NORTH FAMBRIDGE Fambridge Yacht Haven, situated in a mud basin, had a few barnacles, but heavy muddy slime and some juicy sea squirts.

Turn over to find out which antifouling suits your boat

Which antifouling suits your boat?

So which paint should you choose? That depends not only on where you go boating but also the type of boat you have. Here's a quick guide to a few products to look at from three manufacturers for high, medium and low fouling areas: refer to the map on the previous page to find out the level of fouling in your area

CRUISING SAIL

Most cruising yachts will at most scrub off once per season, and many go from launch to haul-out without mid-season attention. To cope with this, manufacturers recommend using eroding antifouling paints, which will continually refresh the surface and biocides exposed to the water throughout the season.

	International	Hempel	Seajet
High	Micron Optima	Ocean Performer	Platinum
Medium	Micron Extra	Tiger Xtra	Shogun
Low	Cruiser Uno	Cruising Performer	Shogun

RACING SAIL

Serious racers need a smooth antifouling finish to reduce friction with the water. This is traditionally achieved with a hard antifouling which can be burnished with a light abrasive. However, both Hempel and International now offer products with a Teflon component to reduce friction, which they say can be maintained by regular scrubbing. For club racers who keep their boats afloat for long periods, International suggest Micron Optima, which although an eroding antifouling is designed to self-smooth.

	International	Hempel	Seajet
All areas	VC Offshore with Teflon/Micron Optima	Hard Racing/ Glidespeed	No specific racing product

DISPLACEMENT POWER

Displacement power vessels have similar requirements to cruising yachts, but pay careful attention to the manufacturer's specification for the maximum speed allowed with your chosen antifouling. The rate of erosion of eroding antifoulings increases dramatically at high speeds and will need to be compensated in the amount you apply. For example, for their Ocean Performer product Hempel recommend that boats travelling at above 15 knots apply an extra coat.

	International	Hempel	Seajet
High	Micron Optima	Ocean Performer	Platinum
Medium	Micron Extra	Tiger Xtra	Shogun
Low	Cruiser Uno	Cruising Performer	Shogun

PLANING POWER

Eroding antifoulings will typically not survive speeds above 25 knots, although Seajet claim 40 knots for many of their products. To combat this, hard paints are typically applied to planing powerboats. Usually, high speeds will dislodge fouling from the hull of a regularly-used boat, but if you only go afloat occasionally you may need to scrub the hull. As with racing sailing boats, you can choose between an antifouling with or without Teflon.

	International	Hempel	Seajet
All areas	VC Offshore with Teflon /Interspeed Ultra/Trilux	Hard Racing/ Glidespeed	Coastal

Stripping and applying Antifouling

As the sailing season approaches, boats begin to start going back into the water. Here's your essential guide to preparing your hull and using antifouling paint. By Ben Meakins

Your boat is sitting in her cradle and spring is in the air: after a winter of hibernation it's time to get down to the boatyard and look nervously at your boat's bottom. But just how much preparation do you need to carry out?

After a few years the thickness of paint on your boat's bottom will inevitably have built up to the point where it has to be stripped back to the bare hull to start from scratch. It's generally recommended that you do this every four to five years with self-eroding antifouling. The good news is that the more antifouling there is on the boat, the easier it is to remove, so it pays to wait a few years between attempts.

First of all, take a good look at the surface of the old paint. Self-eroding antifouling should, as the name suggests, gently remove most of itself during the year – but hard antifouling and many layers of eroding antifouling will eventually build up. Signs that it's time to take it off include:

■ Craters where layers of old paint mean the boat's bottom resembles a moonscape.

■ Flaking where patches of paint have peeled off to leave ragged edges.

■ Blisters where water is trapped under a bubble of paint – usually diagnosed by it being easy to pop. If you suspect the blisters are osmosis, get them checked out by an expert.

If the bottom isn't too bad, you can probably leave taking it all off for another year and just do some minimal preparation this year, preparing the surface and keying it, to take the new paint. We show you why and how on page 86.

Stripping right back

If the bottom's in a bad way, it's clearly time to take the paint off. First, a warning: it's not a pleasant DIY job. You'll rarely meet a boat owner who has enjoyed the experience, and some pay a professional blasting company to come and do the job for them. But for most of us, economy dictates that doing it yourself is the only way.

PBO's editor David Pugh and I decided that live testing was required. The bottom of our test boat, a Sigma 38 named *Gallant*, wasn't too bad, but 21 years of paint had left it pitted in some places, and the performance of the antifouling left a lot to be desired. Owner Paul Fenner, with plans for a season of racing, wanted to know the best method to remove the old paint.

We headed to the Elephant Boatyard on the Hamble River armed with the three main DIY removal methods available:

1. **Dry scraping**
2. **Chemical stripping**
3. **DIY soda blasting**

We taped out a test grid halfway down *Gallant*'s port side and set to work, dressed to the nines in overalls, gloves, eye protection and face masks. It's a lovely job! Afterwards, you'll need to key the surface before painting.

➔

Getting the old stuff off

1. Dry scraping

Scraping is the cheapest way to take paint off. But which is the best scraper to use? We tried three – a traditional flat-bladed 'push' scraper, a triangular paint scraper and a Bahco 'pull' scraper with tungsten-carbide blades.

Flat-bladed scraper

This, sharpened on a grinding wheel and with the corners ground off, was good for lifting flakes of paint off. But for heavy-duty scraping it had a tendency to dig in and try to gouge the gelcoat.

Triangular scraper

Sharpened on a grinding wheel and with its pointed corners ground off, this made light work of 21 years' worth of paint. An advantage is that you have three scraping surfaces to work with, which gives you extra time before it requires sharpening with a file – which needed doing frequently.

Bahco scraper

This type of scraper uses a reversible tungsten-carbide blade. It was so sharp it shaved the paint off unless you got the blade right underneath the paint layer, and its über-sharp edges had a tendency to bite into the paint. But it was probably the most effective. Larger versions have a knob on top for two-handed work that allows you to put a lot of force into it. The tungsten-carbide blade stayed sharp for longer than those of the triangular scraper.

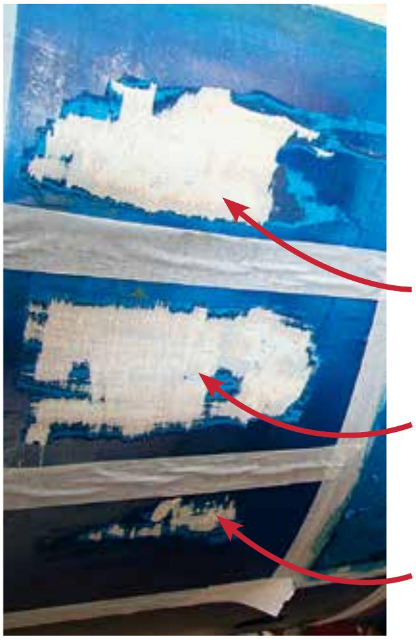
Hi-tech scrapers

PBO reader Philip Stevens uses a Bosch PSE180E electric scraper with the blade's corners rounded off. It's no longer made by Bosch but can still be found for sale on many internet sites. Cheaper alternatives are sometimes available in discount stores like Lidl and Aldi.

'It takes a while to get a feel for the correct angles of use, but is much easier and cleaner to use than a manual scraper,' says Philip. 'A friend did the bottom of his 11.3m (37ft) Moody in a few days.'

Another option is the ProScraper, made by Gelplane International, a 'pull' scraper similar to the Bahco which attaches to a vacuum cleaner to suck up the scrapings as you go. It should make the job less messy and dusty. **www.gelplane.co.uk**

PBO VERDICT: Scraping is quick but very labour-intensive. The Bahco was the best, but the triangular scraper was effective.



These are the results after three minutes of scraping. The Bahco (top) and triangular scraper (middle) were much more effective than the flat-bladed 'push' scraper

BAHCO SCRAPER: quick to use, and the tungsten carbide blades stayed sharp the longest

TRIANGULAR SCRAPER: effective, but blunted easily

FLAT-BLADED SCRAPER: only good for lifting flakes of paint and tended to gouge the gelcoat

TIPS FOR DRY SCRAPING

1 Round the corners off the blades with a file or on a grinding wheel. This will stop them digging into the gelcoat.

2 Keep the blade sharp with a file or change the blades regularly. Hacking away with a blunt blade is just a waste of your energy.

3 Yards like you to clean up after yourself. Lay garden fleece, as used for protecting plants from frost, on the ground first. Water drains through, but dust and scrapings are left behind. At the end of the day you can bundle everything up and throw it away.

2. Chemical stripping

An option which takes some of the effort out of scraping is to use chemicals to strip the paint. You can't just use any old paint stripper, though – it has to be one safe for use on GRP. We tried the three most readily available recommended products: International Paint's Interstrip AF, Owatrol's Marine Strip (formerly called Dilunet) and RemovAll 620 from Cirrus Systems.

Interstrip AF

PRICE: £22.99 **for a 750ml tin**

This product is specifically formulated for removing antifouling. The tin's instructions recommend leaving the product on for 10 minutes before scraping it off with a blunt wooden scraper.

'This is fine if the antifouling being removed is thin,' said International's Richard Jerram, 'but for thicker layers I would recommend that the Interstrip is left on much longer, even overnight'.

We tried scraping after 10 minutes, and the Interstrip had eaten away at the first two layers of paint. We found the best tool was in fact a plastic scraper of the type used to apply filler. Leaving the stripper to work for 10 minutes each time, we got down to the primer after three applications. The Interstrip will leave the primer untouched, ready for the new coat of antifouling.

The tin recommends cleaning up any remaining antifouling with Thinners No3 – which worked, but also started to remove the primer underneath. Finally, a quick wet sand prepared the surface for the new antifouling.

A blunt wooden scraper removed the paint – but a thin plastic one proved more effective

PBO VERDICT: Quick but messy, and the fastest-acting of all the strippers we tried. Left the primer intact beneath the paint.

After six hours, the RemovAll had bitten through the top layer of paint

RemovAll 620

PRICE: £32 (4lt) £142 (20lt)

RemovAll is environmentally friendly and safe on your skin. Depending on temperature, you leave it to work for 1-6 hours. After four hours it had softened the top layer of paint but nothing underneath, so we applied more and left it overnight. In the morning, the paint had begun to lift, so we scraped it off with a plastic scraper. It took off all the paint down to the primer. A further application would have revealed the epoxy coating on top of the gelcoat. It was viscous enough to not drip when applied. The instructions say it can be simply blasted off with a pressure-washer. This worked for a few layers, but in our case would have needed another application if we weren't to resort to a scraper.

A further coat, left overnight, removed the remaining antifouling

PBO VERDICT: Slower acting than Interstrip. Environmentally friendly. Left the primer intact beneath the paint.

Marine Strip

PRICE: £17.99 for a 1lt pot

Marine Strip is sold in most chandleries. It requires 12 hours at least to eat through antifouling, so we applied it and came back the next day. When applying, it was viscous enough not to drip. The instructions say to wait until the paint changes colour. After a few hours, it had darkened and had softened the top layers of paint, but 12 hours later, it was really dark. With a plastic scraper we could then remove all the paint layers down to the primer. It left the primer dry, which would need wet sanding, or another coat of the stripper, before more paint could be applied over the top. It came off as easily as the RemovAll, in soft strips. Like the RemovAll, it can be pressure-washed off, though this was not as effective as scraping.

Left overnight, Marine Strip made scraping the paint off much easier

PBO VERDICT: Slower working and dried the primer out more than RemovAll, but the paint came off in bigger sheets.

TIPS FOR CHEMICAL STRIPPING

1 If leaving for extended periods, ie overnight, cover applied areas with cling film to stop the chemical drying out.

2 Wear eye, hand and body protection. Chemical strippers can burn!

3 Use synthetic-bristled brushes where possible.

4 Especially where there are many layers of antifouling, you may need a number of applications. Chemicals work better in warmer weather.

3. DIY Soda blasting

PRICE: SODA POT £169.95
£29.95 per bag of soda
COVERAGE: 1sq m per bag

Most people bring in the experts to blast off their old stuff, but one way to keep costs down is by doing it yourself. Yorkshire-based company Millar Soda Blasting supply soda 'pots' and the accompanying soda which, when coupled with a suitable compressor, lets you do your own blasting. Company owner Michael Millar made the trip down south to demonstrate the unit. We had a relatively low-powered 13cfm compressor, which meant that the unit's nozzle had to be small. A larger compressor would mean you could use a larger nozzle.

The soda explodes on contact with the hull, removing the paint without damaging the GRP. It ate effortlessly through the layers of paint and primer, leaving the epoxy coating intact, and was by far the least labour-intensive of all the methods we tried. Using the small nozzle, it took Michael five minutes to strip a rectangle 15cm x 25cm. We also tried it on another boat's keel, which was brought back to bright metal quickly and easily, with a residual layer of soda that will protect the metal for up to six weeks. Hard medium can also be added to the soda mix if you need to blast away more than paint.

The kit comprises a 'pot' of soda, and you'll need to hire a compressor

PBO VERDICT: A slow but easy way to remove antifouling. You could save money by grouping together with fellow boat owners to share a blasting unit. Hiring a large compressor (30-40cfm) would make the job much quicker.

The DIY soda blasting option was slow but effortless. A compressor with a bigger capacity would speed things up significantly

Getting the old stuff off – the verdict

So which is the best of the DIY methods we tried? Scraping was by far the cheapest and quickest way – but it's labour-intensive, creates lots of dust and you run the risk of scratching the underlying gelcoat. The chemical strippers were messy and expensive, but did the job well. The ability to paint on and leave overnight makes the job of scraping the hull next day far easier than dry scraping. And finally, soda blasting is the least labour-intensive – but was extremely slow. A bigger compressor would sort that out. It's cheaper than getting someone else to do it – but takes time. If you can afford it, paying someone else to blast it off might not be a bad idea!

Preparing to paint

Top tips for a great finish

You may be lucky this year. If your boat's bottom has a half-decent finish, you can postpone the job of removing it till another year – but you will need to key the surface to ensure that the next layer of antifouling sticks to it. Even if you've removed your paint, you still need to key the surface.

A coarse, 40- or 60-grit wet/dry sandpaper used wet to keep dust down should do the trick. Use plenty of water to avoid clogging the sandpaper and, if it's cold, consider using warm water and household washing-up gloves.

Change sandpaper regularly, as soon as it begins to lose its bite.

Barnacle remains need very thorough treatment as their cement contains a hormone which encourages young barnacle spat to settle nearby, so sand off all this cement until none is left.

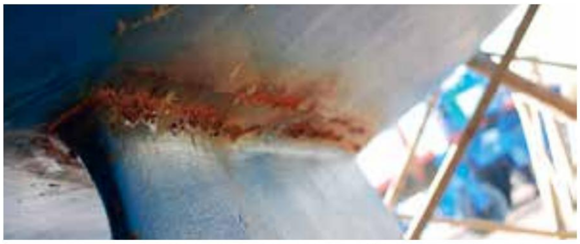
If you can organise it, cleaning off the hull like this is actually a job best done soon after the boat comes out of the water. Old antifouling and marine growth is easier to remove before it hardens out of the water over winter – and it saves time in the springtime.

Keels can be primed, filled and faired to create the best finish

Keels

Once a steel keel has started to corrode and become pitted it can be hard work to restore its smooth finish. The trick is to remove the paint first. Then you can begin to tackle any rust. Use a wire brush, angle grinder, drill attachment or blasting to begin to take the keel finish back to bright metal. Apply a rust converter such as Fertan to get rid of the rust. Once you've done that, fill any major voids with glassfibre filler paste. It's a slow process. If there's any damage to the leading edge from grounding, you can build that back up with glassfibre paste, too. Once you've got the keel to an acceptable finish, it's time to prime it with epoxy primer, to seal it, before proceeding to prime and antifoul it.

An area most likely to show signs of corrosion is the keel root. On many boats this is marked by rusty dribbles, although in many cases this is just an irritation rather than being symptomatic of a deeper problem. To be sure, give the keel a side-to-side wiggle when the boat is in the slings to make sure it isn't moving – if it is, consult a professional to have your keel bolts checked.


This sort of rust around a keel root is common and not a terminal problem

If, as is most likely, the rust is just cosmetic, you can take the visible bits of keel back to bright metal before priming them with rust-remover. You can them prime them with epoxy primer to stop any water ingress, before sealing the gap with Sikaflex or another flexible underwater sealant. Before you antifoul, consider a further coat of a tie coat primer like Primocon before you paint on the antifouling.

Propellers and stern gear

There are a number of options when it comes to stern gear. Some people like a highly polished finish to the metal so fouling can't get a grip, others prefer to paint it with a hard antifouling or specialist propeller paint, like Seajet's Peller Clean, while some coat it in lanolin or similar grease, such as Propshield or Dr Barnacle. I'm sending mine off to a machine shop to be polished to a high gloss.

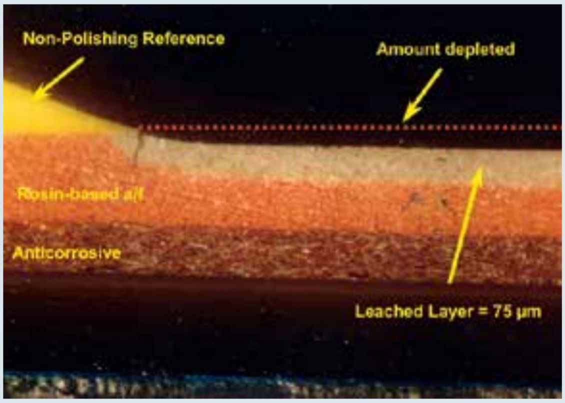
One option is to antifoul your propeller with a special coating

Why bother? The importance of preparation

This magnified image is a cross-section of a self-eroding antifouling paint. International Paints' Chris Jones explained: 'The yellow bit on the left-hand side is a control section which shows the paint as it is when applied new.'

The gap between the horizontal red dotted line and the pale cream section (leached area) is where the paint has eroded when the boat moves. The leached area is the part of the antifouling film which has lost all its biocide through leaching, but because the boat has not been used enough, the dead paint has not been eroded away. This area dries out and becomes brittle and unstable. You can see a small crack in the film on the left side next to the yellow section which highlights how brittle the film can become.

The leached area needs to be wet-sanded away to go back to the stable biocide-rich remains of the old paint (orange section) before a new season's antifouling is applied on top. If the wet sanding is not done, it is likely that the old antifouling would flake off on the roller as the new paint is applied or the new paint will fall off underneath the water when the boat goes back in – neither of which are desirable!



Putting on the paint

When choosing your antifouling you'll be presented with a dilemma. You need to find out what will work best on your type of boat and which will be most effective in the area you keep her. As a starting point, there are three main types of paint to choose between:

- Eroding
- Hard film
- Copper-based

Eroding antifoulings use the water's friction to reduce the thickness of the paint and expose fresh layers of biocide. This erosion releases biocides in a controlled manner, providing a longer and more consistent performance throughout the season. It also helps to reduce long-term build-up of antifouling.

A large sponge or short mohair roller will make light work of any boat's bottom – two coats are normally required

High-speed vessels, boats on drying moorings and racing boats require a hard film antifouling rather than an eroding one. This stops the increased pressure on the hull, whether from high speed, silt and mud or scrubbing, from removing the paint film too quickly. These antifoulings work because the biocide leaches out of the paint without the paint film eroding away.

Another variety with a dedicated following is copper-based paints. These use particles of copper suspended in an epoxy coating and can last up to 10 years, saving you the annual ritual of antifouling.

Copper-based paints are significantly more expensive than standard antifoulings, but will last a great deal longer. Their application is not covered in this article, but they're worth looking at as a long-term solution to fouling.

Each manufacturer will be able to recommend a paint for your type of boat and level of fouling. To get an idea what fouling you might expect in your cruising area around the UK, and what's likely to work best to combat it, turn to page 78.

As a general rule, however, it really depends where you are and what you are prepared to pay – the more you pay for effective antifouling paint, the better the results regardless of where you are.

When it comes to local variations, it's a good idea to ask around your local sailing community to find out what type of antifouling seems to be working best for your type of boat.

Priming

Whether you've had to remove all the old antifouling or are just putting more on this year, you should consider priming the hull. A tie-coat primer ensures the antifouling will stick properly. If simply overcoating the existing paint, you'll probably get away without it – but you need to check that the new and old paints won't react with each other. Most modern paints should be compatible with each other.

If you've taken the existing antifouling back to the yacht's gelcoat or epoxy coating, it's recommended that you paint the hull with primer to ensure good adhesion. If your existing paint is flaking, you need to prime any bare or flaky patches. Scrape away until all the flaky paint has come off, then feather the sharp edges of the paint that's left by wet sanding them.

Generally speaking, self-eroding antifouling can be safely applied over the top of hard, but applying hard over self-eroding should be avoided. Specialist racing antifoulings, especially those containing Teflon, are generally incompatible with other coatings – it's worth checking the tin and data-sheets carefully.

If you are in any doubt about compatability, apply a tie-coat of the recommended primer – it's a lot cheaper and quicker than scraping everything off after a bad reaction and having to buy a new tin of paint!

What's in your antifouling?

Antifouling paints are expensive for good reason – they're a complicated formula designed to work in very testing conditions. But what actually goes into them? Here, as an example, are the contents of a typical antifouling paint:

GUM ROSIN A natural product harvested from various species of pine trees around the world, gum rosin is used as a binder when dissolved in solvent. It's soluble in seawater, which allows a controlled release of the biocide mixed with it. Acrylic is used as an insoluble binder when dissolved in solvent. A high acrylic/low rosin ratio is used in hard, slow-release paints, whereas a low acrylic/high rosin ratio is used in high eroding paints. Rosin can leave a dead matrix on the surface of the paint, blocking biocide release, leading some manufacturers to replace it with an acrylic polymer for cleaner erosion.

PLASTICISERS are added to increase the flexibility of the paint – gum rosin is a very brittle material, which on its own can cause the paint to crack.

THIXOTROPES, normally clay and fumed silica, are added in small quantities to ensure the product does not settle in the tin, to maintain optimum viscosity and to minimise runs and drips.

COPPER OXIDE is a biocide which is effective against both animal and weed fouling.

PREVENTOL A4S is a biocide, effective against weed.

ZINC OXIDE is slowly soluble in seawater which allows it to help control the polishing rate. It also absorbs UV which can attack the sensitive biocides, especially at the waterline.

EXTENDER PIGMENTS, which include talc, China clay, gypsum (plaster of paris) and barium sulphate are used to adjust the binder-to-pigment ratio which in turn affects the paint film properties, such as permeability of water and blistering. Careful selection of the extender pigments is particularly important as their particle size and shape greatly affects their performance.

SOLVENT XYLENE is used to dissolve components of the paint. The evaporation of the solvents causes the paint to dry and form a film.

Application

After all the preparation, you're finally ready to paint. This is the fun part. Ideally apply it in the late morning or early afternoon in calm, dry weather to avoid the risk of dampness or overnight dew.

Sometimes you may need to put a plastic sheet down to protect the ground, or wet the surrounding area to prevent dust rising onto your paint surface. If you're painting on a cold day, keep the tin in a warm place before use, or in a bucket of warm water to help make the paint flow more easily. How much you need to apply varies – but most paints require at least two coats.

1. Using a wide stick, stir the paint well. Biocides are heavy and will sink to the bottom of the tin, so stir vigorously and for longer than you think is probably necessary.

2. It's best not to mix old and new batches of paint in a tin – they may not react well together. If you do, use a roller tray, with small amounts at a time.

3. Pour a small quantity at a time into your roller tray – that way if you drop it you won't lose too much. Replace the lid on the tin, too.

4. Apply the paint in a logical fashion. One PBO reader kept track of which bits he'd painted by drawing chalk lines at roughly 1ft intervals: these disappeared under the new paint.

5. Use a brush for fiddly bits around transducers and stern gear. For a really smooth finish, someone can follow you with a pad to smooth out ridges and dribbles.

6. If you have enough paint, apply an extra coat along the waterline and leading edges of keels and rudders – all areas that are high wear.

7. Paint around the cradle pads (see next column).

Paint around the pads, then wait for the yard to shore the boat up and lower the support

Which roller to use

It's best to use a short mohair or sponge roller suitable for gloss paint. Rollers designed for emulsion will disintegrate very quickly, leaving bits of fluff all over the newly painted surface. Some people find smaller, radiator-size rollers with long handles are easier to use with thick paint, but coverage will take longer.

Cradle pads

Painting under the cradle supports is a common problem for boat owners. The time-honoured solution is to paint around the support, then get the yard to move it before painting the bare areas. If they won't do that, you can slap some paint on while the boat is in the slings – but this won't give you the required two coats or, with most paints, the correct drying time. If you chock the boat and remove pads one at a time, make sure the paint is dry before you put the pad back or it'll stick to the paint.

Mask a straight line

We've all seen boats with a wobbly boot-top. The trick to getting it straight is to take your time.

Use a number of bits of masking tape to ensure a fair curve around the stem

First of all, use a good-quality tape to ensure paint doesn't 'creep' underneath it. Try to get a stepladder or a low scaffolding at a height so the stripe to be masked is at eye level. Even better, have someone else look along the line while you stick it on. Pull out a long length of tape, and gently lower it to the hull while looking along it. This will give you a much fairer, even line than if you stick it down at short intervals. Stand back every now and again to check. When you get to the bow, use a number of pieces of tape to keep the line straight and level as it goes around the curve.

Taking your time masking the boot-top will give a better finish

TIPS FOR PAINTING

1. Keep a rag and some thinners handy for the inevitable splashes and drips. That way you can remove them easily and quickly.
2. As soon as the final coat feels tacky, remove the masking tape – it'll be difficult to get off later on.
3. Don't apply the antifouling too vigorously or try to stretch it too far: if you do that you will run the risk of disturbing the primer below.

And finally, sail more!

Unfortunately, no antifouling is going to keep your boat completely slime-free. But the more you use your boat, the better the antifouling works, as International Paint's Richard Jerram reminded us: 'Antifouling paint always works best when the boat is well used as they are developed to work when in motion. So if you want a completely clean hull then choose the most appropriate antifouling and get out onto the water.'

The *Moquini* was found off South Africa without a keel in 2006

Master of the Algarve/MRCC

Avoid potential disaster with these simple

DIY keel bolt checks

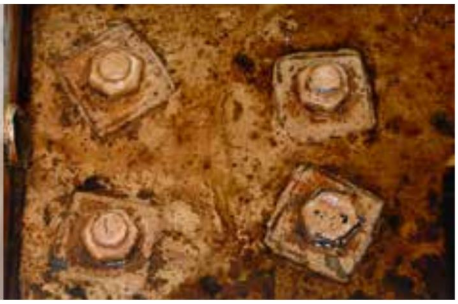
Colin Brown describes a series of checks you can carry out to assess the structural integrity of the bolts which attach the keel to your boat

There have been some high-profile keel losses in recent times, and this has focused attention on keels and how they are held on. However, before you pale in fear, it's important to remember that there are thousands of boats sailing around, and it is virtually unknown for a keel to just fall off. Many of the warning signs of keel attachment weakness are detectable with some simple checks that you can carry out yourself.

The tests described here are mainly aimed at fin-keeled boats with external ballast, as these are more prone to issues with their keels in comparison to long-keeled boats and those with encapsulated ballast. I've used the term 'bolts' to describe both keel bolts and studs throughout this article.

When a boat loses a keel at sea the first reaction is often to blame the keel bolts, but the evidence does not support this; and other failures are actually more common. In 2008, the International Sailing Federation (ISAF) set up a working party on keel losses, and they found 72 cases since 1984 of boats losing their keels. There were defined causes in 44.5% of cases, but only three were attributed to keel bolt failure. Other causes included welded fin failures (11), grounding collision (8), internal structure (8) and canting keel system (2).

This may be reassuring, but it does indicate that our checks need to be wider than just looking at keel bolts. I'll outline the basic checks, but if you have any concerns get an expert to check your keel in person.



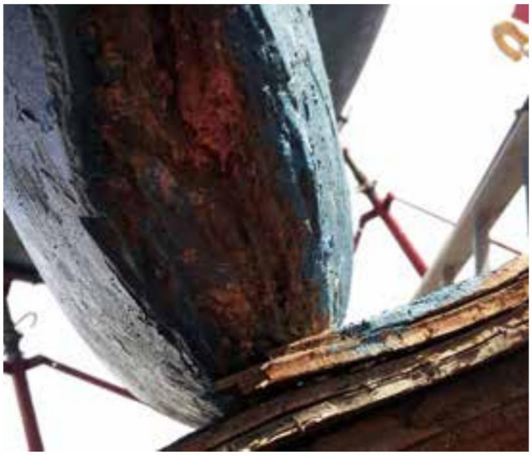
When a boat loses a keel the first reaction is often to blame the keel bolts: but other failures are actually more common

ABOUT THE AUTHOR

PBO Expert Colin Brown runs the marine survey and consultancy company, CB Marine Services

Internal ballast

If you have encapsulated internal ballast, then look for swelling or splits around the keel: in particular, check the leading edge and underside of the keel where it may have hit obstructions. Damage can let water in round the ballast, and iron ballast will swell as it rusts and can split the ballast top or cause bulges in the hull. Lead won't rust or swell, but trapped water will swell if it freezes. If you suspect the keel has hit something (you may even have been at the helm at the time!), check internal structures for cracks and delamination.

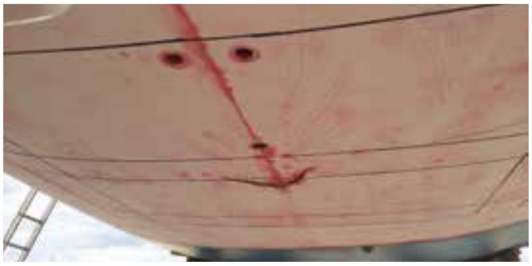


This keel had clearly suffered some damage, and the layers are visible on the bottom of the keel. The ballast was lead and there was no swelling, although there was water weeping out from other parts of the keel. The damaged laminate should be ground back to let the water out

External ballast

It should be safe to assume that keel bolts have been specified by the designer to have an infinite fatigue life. This means that loads applied to them in normal use will never be high enough for fatigue to be an issue. Fatigue should only be an issue where corrosion has removed load-bearing area from the bolts. We can't assume an infinite fatigue life for a hull, but normal use should not cause structural failure. Time will tell how long modern hulls last, and no boats seem immune to manufacturing defects. In all cases, seemingly small failures can allow the keel to move and this can spread to widespread separation of structures, loss of strength and ultimately to keel loss.

There are a number of signs that might indicate all is not well with your keel and its supporting structures. The checks listed below should take place after any grounding, and if you have never done them before. If in doubt, seek advice from a surveyor or an experienced repair yard. If you contact your insurance company they may appoint a surveyor of their choice.

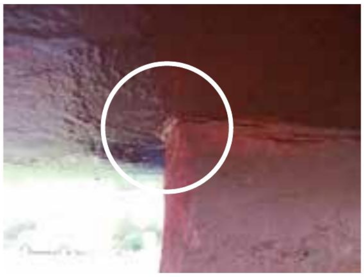


GROUNDING DAMAGE. The puncture at the keel's aft end is obvious. Less obvious are the external cracks reaching almost to the waterline and widespread separation of the internal reinforcing grid

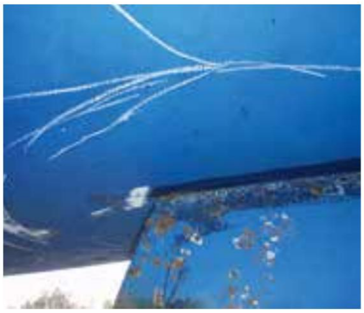
External checks with the boat ashore

- Is there a gap between the keel and the hull? When the boat is lifted from the water, look at the hull-to-keel joint: it might seem a statement of the obvious, but check to see if there is a gap between the keel and the hull. Does the gap close when the boat is put down? A hairline crack in the antifouling is normal at a hull-to-keel joint, especially if flexible sealant has been used to seal the joint.
- Are there rusty streaks from the hull-to-keel joint? It can be hard to judge the origins on an iron keel, but rust streaks on a lead keel with stainless steel bolts must be taken seriously.
- When the hull has dried out, is there water still leaking from the hull-to-keel joint? This is a clear sign that, at the very least, the seal has failed.
- Can you see cracks or damage on the hull? The keel may have moved and dislodged some paint. You may have to remove the coatings to expose the hull, but in some cases the cracks are visible through the coatings.
- Can you make the keel swing? Another obvious test is to push the bottom of the keel to see if you can move it. Does it swing when you let it go?
- With the boat resting on the keel, can you see any upward deflection of the hull? This can sometimes be seen aft of the keel where the hull should be flat and is less likely if there is a keel stub.

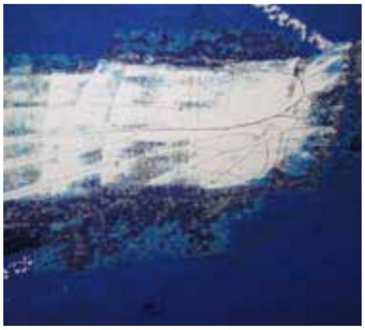
Failure in any of these tests suggests that the keel structure may have been weakened, and further investigation and probably repair is required.



Gap at the aft end of a fin keel. The keel moved at least 5mm as it touched down. Sealant had clearly been added externally



Cracks visible through the antifouling were traced out with chalk to make them show up

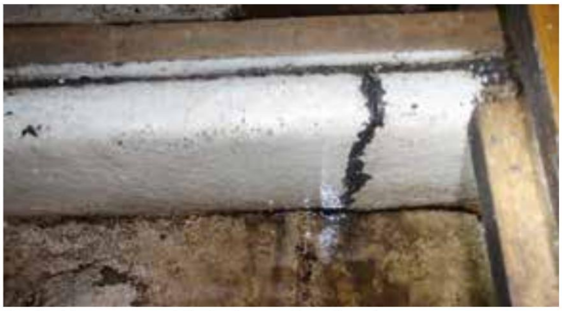


The same hull below the coatings

Internal checks with the boat ashore

- Is there water in the bilge? Leaking keel bolts are a sure sign that all is not well, particularly with stainless steel. Check for other more obvious leaks, including the plumbing, to eliminate them before tackling the bolts.
- Look closely at the keel bolts, nuts and washers. Use a wire brush to remove built-up crusting and debris. Steel bolts often look terrible at first, but further investigation might reveal no significant loss of material.

  Nuts can be removed to allow inspection of the threads below. New nuts may be needed if there is any damage to the old ones, either from rust or removal.
- Rust stains round stainless bolts should be taken more seriously. If you believe your stainless steel keel bolts have been wet for some time, you must suspect that they are corroding and take action to investigate.


Cracked frames around the keel are a clear sign of excess movement

- Is there any sign that the bolts have moved? Check for telltale marks on the hull which may indicate this.
- Are the nuts loose? Quick application of a hammer or spanner may reveal a lot.
- Are the washers flat? Enlarged holes and re-tightened nuts may deflect washers into a cup shape.
- Glassed-over studs may have rust stains visible, and a light hammer may reveal one that sounds different from the rest.
- Do the sole boards fit, and do the doors still open and close? Both would indicate that the hull has changed shape. It could be that structures have been weakened or broken.
- Look closely round the structures that support the keel. You may have to remove screwed-down sole boards. Cracks are a sign of movement beyond design, and a light hammer can be used to find areas where the structures are no longer stuck to the hull.
- Are there obvious signs of repair? Is there any record of the repair? Poor finish and different colours are easy to see (as is dust) in hard-to-reach spaces. Signs that the keel was not removed, such as resin over the keel bolts or repair edges around the keel bolts, might be signs of inadequate 'sticking plaster' repairs.

Poor repair work is easy to see, and in this case it was ineffective as the sole boards didn't fit and the hull was deflected upwards aft of the keel

- Painted studs and nuts may be a sign of good maintenance but could also be an attempt to hide something.

How to fix it...

If you suspect that your keel bolts are rusting, the only way to be sure is to lower the keel to have a look. This should not be taken lightly and will probably require a hoist or crane to support the boat. It may be possible to open a gap without dropping the keel completely. Have a strong structure ready to support the keel.

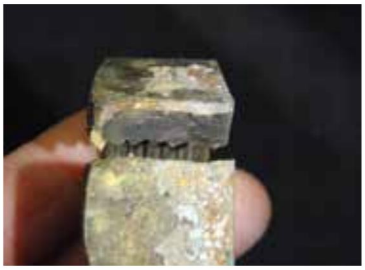
Even leaking and damaged keels may not lower easily, and some may have to be chiselled off.

If you find or suspect damage to the internal structure, then a full repair is likely to be complex and expensive and will probably require the keel to be removed to allow the hull to regain its proper shape. A few bits of matting and resin are seldom enough to replace lost strength.

As stated previously, if you're in doubt you should seek advice from a surveyor or yard with experience of keel repairs. If you suspect you have a problem, contact your insurance company as you may be able to recover some of the cost.

If lowering the keel, have a strong structure ready to support it

This lead keel had to be chiselled off, hence the chisel marks


A broken bronze keel nut. You can see the brittle fracture zone along the outside. No crack was visible until the nut was removed

Dust in out-of-the-way corners is a sure sign that a grinder has been used

How to service your seacocks

Seacocks require regular inspection and maintenance: David Pugh shows how

Some things are best preserved by leaving well alone, but seacocks aren't among them. Regular manipulation of your seacocks not only helps make sure your pride and joy is still afloat when you next return, it also assists in keeping the grease well distributed and shifting accumulations of scale and debris, both of which can accelerate corrosion and cause seacocks to seize.

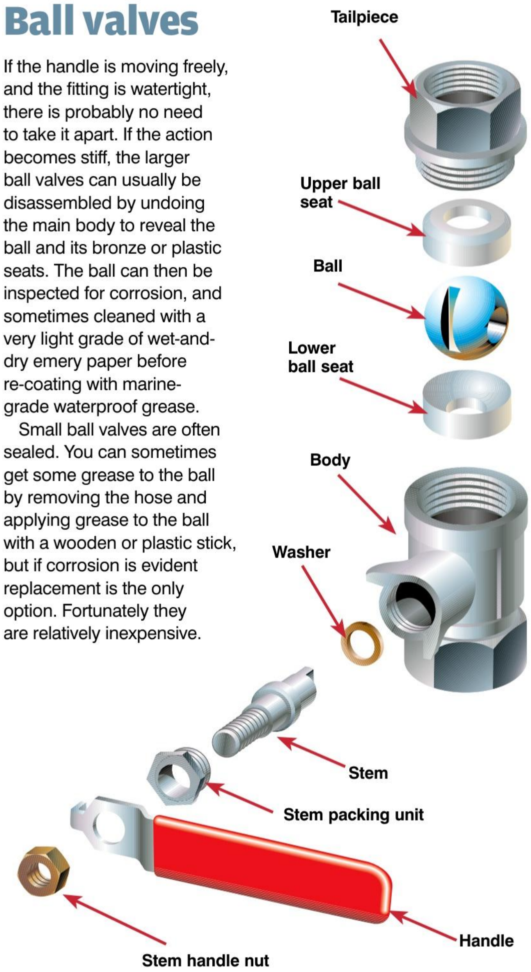
Older boats are often fitted with cone-type seacocks, the most common make being Blakes. Modern designs are more likely to be fitted with ball valves. Materials vary: older seacocks are nearly always bronze, but more recently other materials have appeared on the scene. In most cases, including modern Blakes valves, bronze has been replaced by DZR (dezincification-resistant) brass, but ball valves, or at least the ball within them, are often made from stainless steel. Fibre-reinforced plastic is also becoming increasingly common. It's essential that any brass fittings used on board are DZR, as cheaper alloys will quickly degrade in seawater.

Types of seacock

Ball valves

If the handle is moving freely, and the fitting is watertight, there is probably no need to take it apart. If the action becomes stiff, the larger ball valves can usually be disassembled by undoing the main body to reveal the ball and its bronze or plastic seats. The ball can then be inspected for corrosion, and sometimes cleaned with a very light grade of wet-and-dry emery paper before re-coating with marine-grade waterproof grease.

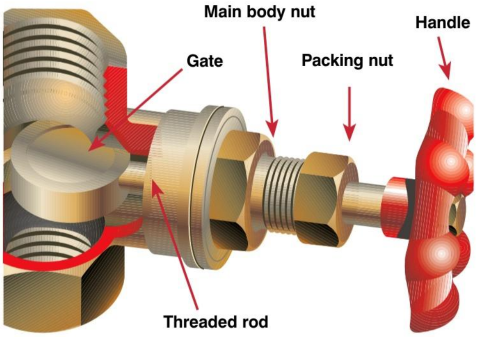
Small ball valves are often sealed. You can sometimes get some grease to the ball by removing the hose and applying grease to the ball with a wooden or plastic stick, but if corrosion is evident replacement is the only option. Fortunately they are relatively inexpensive.



Gate valves

Most of these fittings are made from cheap metals such as brass, and happily corrode in a salty environment. The wheels fall apart, and the threaded stems break, leaving the gate irretrievably stuck. Gate valves are not true seacocks, as it is almost impossible to tell if they are open or closed unless you actually try the wheel. If you have gate valves aboard, the advice is to exchange them for either a ball or cone seacock at the first opportunity.

Annual inspection and greasing is essential. Remove the valve body and take it apart to reveal the gate, and inspect all parts closely for corrosion, especially around the threads. A common cause of leaking is due to damage at the bottom end of the gate, where it has been screwed down onto a hard piece of debris and scored. When reassembling, make sure the gate is screwed back to the right position on the stem before tightening up the main housing nut.



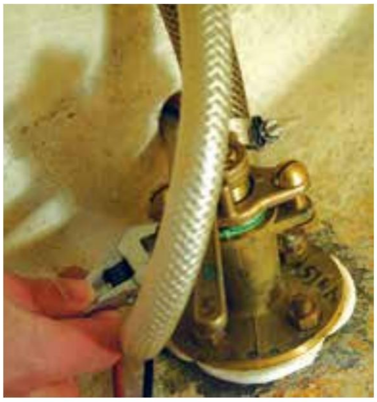
Plastic seacocks

Although plastic and composite seacocks are immune to corrosion, they still require maintenance on a regular, preferably annual basis. Actuate the handle and lubricate the seals according to the manufacturers instructions – they usually recommend a lanolin-based grease.

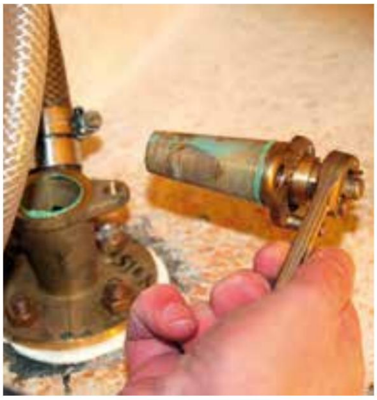
Servicing a Blakes-type valve

Annual cleaning, inspection and greasing will guarantee long life. Newer versions have grease nipples fitted which allow you to use a grease gun to inject grease mid-season and can reduce the regularity with which you need to fully dismantle the seacock, but it's still a good idea to do it every two or three years to allow you to clean out old grease and inspect for corrosion. Older types should be dismantled annually.

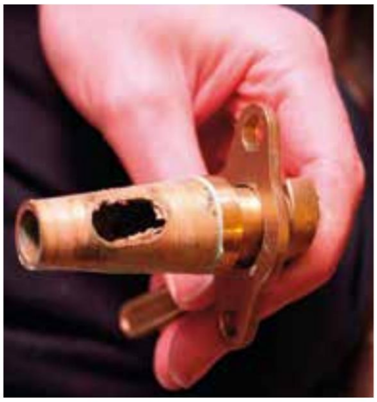
The following steps show how to dismantle and grease a Blakes-type seacock. If you find that the cone or seat is pitted, you can grind out small imperfections by cleaning the surfaces and applying grinding paste before rotating them against each other to remove some material. Once ground back, clean the valve again and reassemble with plenty of waterproof grease.



1 Undo the locknuts, remove the screws securing the top plate to the body...

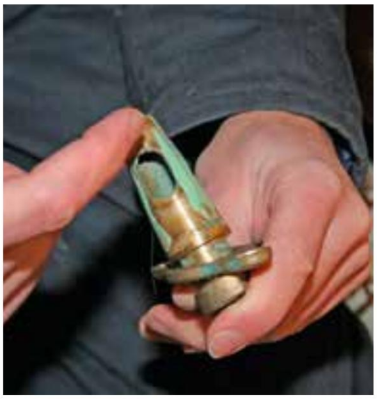


2 ...and withdraw the cone and plate. Wipe old grease out of the barrel.



3 This cone appears to be in pretty good order...

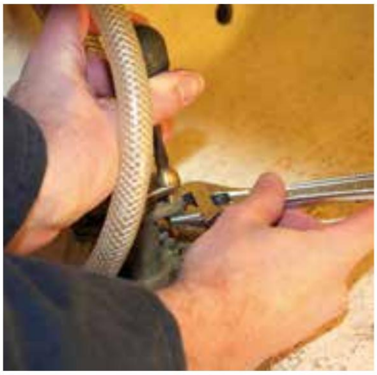
4 ...but we wipe off the old grease and apply new anyway. If the grease is difficult to remove, diesel is a useful solvent.



5 Apply a good-quality waterproof grease evenly over the cone...

6 ...then re-insert it into the barrel and work it back and forth to distribute the grease around the cone and barrel.

7 Refit the screws, tighten them to the point when the seacock is about the right stiffness, then back them off about an eighth of a turn.



8 Holding the screw with a screwdriver, replace and tighten the locknut.

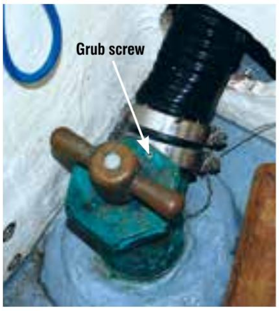
9 The locknut takes up the last of the slack. The seacock should move smoothly with moderate resistance.

How to service flush-fitting seacocks

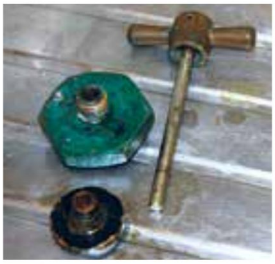
Many boats in the 1970s and '80s were fitted with Elanco flush-fitting seacocks. Made by Landamores in Norfolk and consisting of a high-quality bronze body with a plunger that, when closed, seals the opening flush with the hull, they found favour with owners looking to keep their boats' underwater profile as smooth as possible.

They can still be found on Hustlers, UFOs, early Oysters, Impalas and other cruiser-racers from that era, and whole units and spares are still available from Landamores (www.landamores.co.uk).

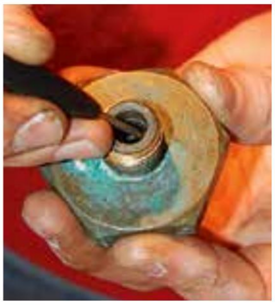
These seacocks should be serviced annually. If the stainless shaft is pitted, it can be easily replaced using ⅜in diameter 316 stainless steel rod.



1 With the boat ashore, remove the Allen-head grub screw on top of the seacock and unscrew the cap: you'll need a big spanner.

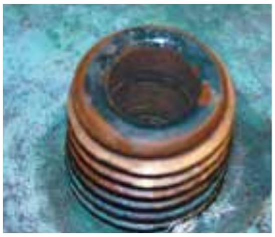


2 You need to remove either the handle or plunger end from the shaft, it doesn't matter which. Both have a grub screw that needs to be removed before the shaft can be pressed or driven out.



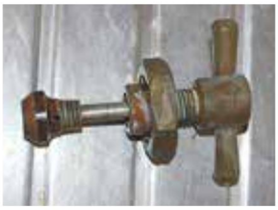
3 Remove the old O-rings. There are two inside the top casting – a small screwdriver or perhaps a sailmaker's needle will be needed to remove them.

4 Remove the old neoprene seals. There is a large one located just inside the thread on the top casting, and two smaller ones – one inside the handle and another inside the insert.



5 Fit the new O-rings. This can be very fiddly as both need to fit perfectly into their recesses deep inside the shaft tube. The blunt end of a softwood skewer can prove useful for this.

6 Fit the new neoprene washers – a simple job by comparison with the O-rings.



7 The shaft can now be slid through the cap and the ends reattached. There was a noticeable difference in that there was much more friction from the new O-rings – a sign of a good seal!

8 Reinstall the assembly in the seacock body, tighten the cap and do up the grub screw.

TIP

Keep a selection of tapered softwood plugs handy to seal pipes or holes if necessary

Dealing with seized seacocks

Lack of grease or a build-up of scale from insufficiently frequent maintenance can cause the moving parts of a seacock to bind to the valves' body. A blow with a hammer may snap off the handle, so try running in some easing oil and leaving it to work overnight. Boiling water or a hot-air gun can cause enough expansion of the metal to break the seal – gentle tapping with a rubber hammer may free the valve once these steps have been taken.

Blakes

With Blakes-type valves, the keeper plate can be removed and the plug driven out from outside the boat by inserting a soft metal or hardwood drift (a broom handle may work) into the outlet and striking it with a hammer. Regrinding the offending plug with medium grinding paste will give a key for the grease to hold onto upon reassembly.

Gate valves

Gate valve seizures are usually terminal, and the result of advanced corrosion. The wheel may well shear off if too much pressure is applied. Try the techniques already mentioned to free a jammed valve, and schedule it for replacement at your next refit.

Making a mould

You can save a small fortune by making your own items out of glassfibre, but first you'll need a mould from which to take them. Jake Kavanagh explains how it's done

With a bit of know-how and an ability to think 'back-to-front', any competent DIYer can produce excellent GRP mouldings for around a tenth of the retail price. Even the materials for the moulds can be sourced from scrap.

What's in a mould?

Polyester resin is stored as a fluid, but when triggered with a catalyst it will quickly harden into solid plastic. Like most resins it won't bond to anything shiny, so flat sheets of GRP can be laid up on a pane of glass, or against a shiny PVC extrusion. Parcel tape also seems to resist the adhesion of resin with ease.

When you paint catalysed resin into a mould, it will faithfully reproduce the mirror image of whatever it sets against – including, unfortunately, every imperfection.

This is why mould making is so time-consuming. If you want a showroom finish the surface you are going to mould against has to be as perfect as can be. It also has to be liberally coated with multiple layers of release wax, so you can detach your product (known as a moulding) without a struggle.

A mould can be made from anything solid and non-porous. Fibreboard is a popular choice, as it is easy to cut, shape and sand. Plywood, hardboard and some plastics are also good for moulds, but the key element is that they must have a smooth surface to mould against. The quality of the surface of the mould will be mirrored in the moulding. This shiny surface can be created with a few layers of hard gloss paint, and then polished till it gleams nicely.

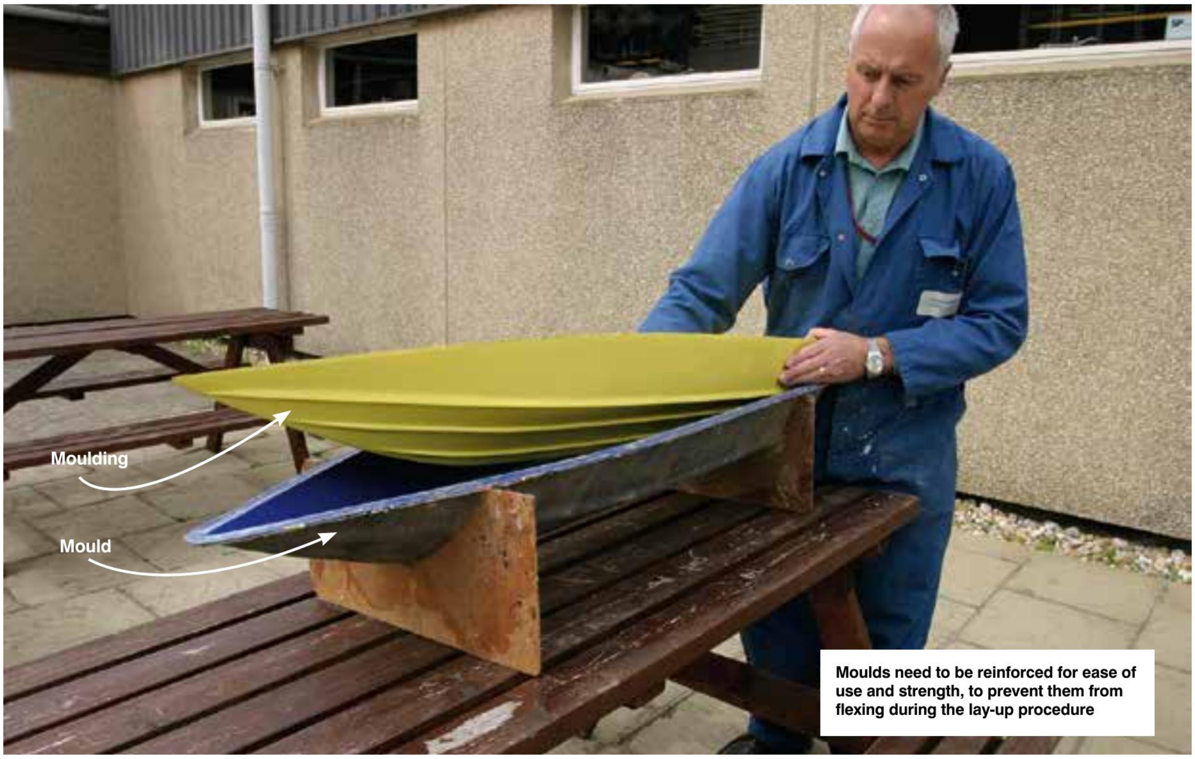
Keeping it rigid

Finally, the mould has to be rigid, so it doesn't twist or distort when the moulding is being created. Even quite small moulds should be braced with pieces of timber or ply.

To hide the fibres of the glass reinforcement, most GRP mouldings have a thin layer of pigmented resin called a gel coat. When making a moulding, this decorative layer is the first thing painted onto the pre-waxed mould, followed by the layers of glassfibre saturated with resin. The last things to be added are reinforcements such as strips of wood or foam. When the whole moulding has hardened, or 'cured', it can then be released from the mould.

Making a mould for just one item is probably inefficient compared to other methods, such as tape-and-epoxy plywood construction. There is more work, as you effectively make the same item twice – the mould itself, then the moulding. But as one mould can produce an infinite number of mouldings, it really pays off when you need a number of identical items.

We could have made the anchor locker in this example in less than half the time using plywood saturated in resin and with taped edges, but it still takes some extra effort (grinding the seam edges flat, filling and flow-coating) to make this kind of construction look professional. It's not a problem if you're not a perfectionist, or looks don't matter, but we wanted our locker to look like original equipment. So a mould and moulding was the route to take.



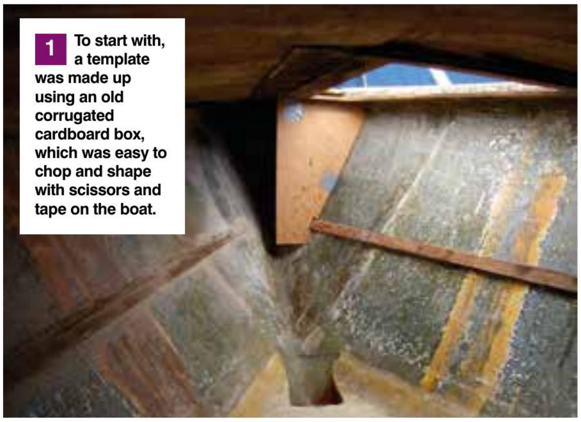
Moulds need to be reinforced for ease of use and strength, to prevent them from flexing during the lay-up procedure

STEP 1 Templating

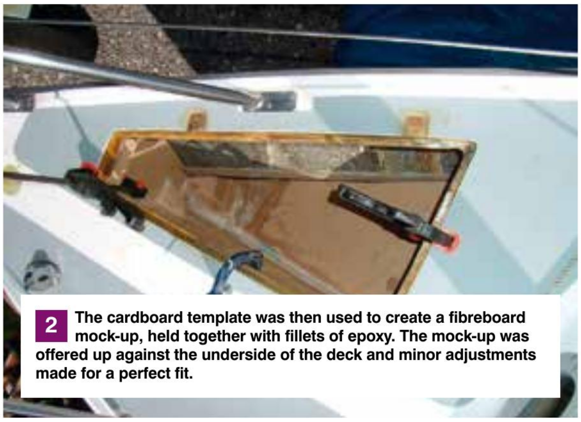
The idea was to create a locker under the foredeck with the shiny gelcoat facing into the locker, and the rougher reinforcement side facing out into the cabin where it would be covered in vinyl headlining material. It's important when designing a mould to know which side you want the gelcoat to be

MATERIALS:

- Cardboard and sticky tape for making templates
- 9mm fibreboard, hardboard or melamine to make the mould
- Primers, fillers and hard-wearing paint for the finish
- Release wax



1 To start with, a template was made up using an old corrugated cardboard box, which was easy to chop and shape with scissors and tape on the boat.



2 The cardboard template was then used to create a fibreboard mock-up, held together with fillets of epoxy. The mock-up was offered up against the underside of the deck and minor adjustments made for a perfect fit.

3 This mock-up goes on to become our male mould, so it needs to be properly and carefully prepared. The corners and edges are smoothed off and any imperfections filled with a suitable filler.

4 Now layers of paint are built up, starting with a primer, to create a shiny surface. Each coat is carefully sanded flat and, again, any minor imperfections filled with a smooth-sanding epoxy filler.

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Mould making tips

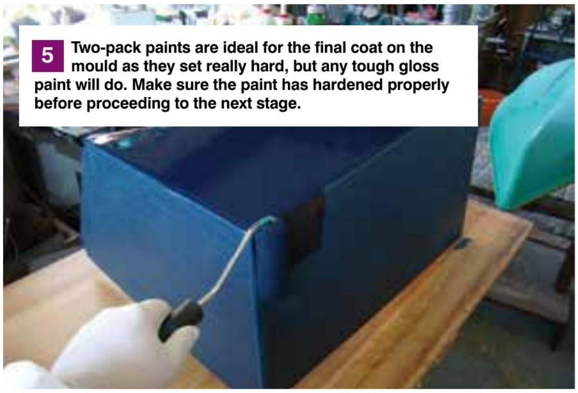
1 Make sure the shape of the mould is slightly tapered to allow the moulding to be released, otherwise the mould will have to be destructible, or in two or more pieces.

2 Choose a paint colour for your mould that is different from the gelcoat you will be using. This makes it easier to see how well the mould is being covered.

3 To reduce clogging when you are using wet-and-dry paper, add a small amount of detergent to the water. To avoid impurities, use fresh water every time you change to a finer grit.

4 When cutting back mould paint, avoid silicone compounds: they ruin the mould's ability to support wax.

5 New moulds can be temperamental when it comes to removing the first moulding. Apply at least five layers of release wax, allowing a good hour to dry between each one.



5 Two-pack paints are ideal for the final coat on the mould as they set really hard, but any tough gloss paint will do. Make sure the paint has hardened properly before proceeding to the next stage.

6 Despite our best efforts, some bits of grit and dust still found their way onto the painted surface, which the mould would faithfully reproduce. To remove these, the gloss was carefully sanded with wet-and-dry sandpaper, used wet. Sanding begins with 400-grade paper followed by 600-grade, then 1,000- and finally 1,200-grade.

7 Fine sanding leaves the paint surface perfectly flat, but it has lost its all-important mirror-like gloss in the process. A shiny moulding needs a shiny mould, so we have to get the gloss back.

8 The gloss is restored with a cutting compound, such as Farécla G10, or 3M Supercut. We're using it with a lambswool bonnet on a random-orbit sander, and it only took a few minutes to restore that glossy finish.

STEP 2 Waxing

After applying the first coat, leave it for an hour to harden and then buff it up to a shine with a polishing cloth. Repeat this process for each subsequent layer. Waxing can be done at leisure, so you could put a coat on before you go to work, and another when you get home.

Many professionals also use a PVA release agent as a 'belts and braces' approach to back up the wax, but it's not essential. PVA is a liquid plastic suspended in alcohol, and is simply wiped on to the last layer of wax. Applied thinly (as if wiping down the kitchen drainer after washing up) the alcohol evaporates, leaving a very thin layer of plastic behind. This greatly assists the release of the first moulding. The PVA (coloured blue in this instance) will stick to the finished moulding when you take it out of the mould, but is easily washed off with water.

1 Using a clean cloth, apply the wax evenly all over the mould. Keep the coverage flat and even, and avoid any ridges of wax. Pay particular attention to corners and edges where it's easy to apply the wax too thinly.

2 As being demonstrated on this sheet of melamine, PVA needs to be wiped on and wiped off to leave a very thin film of plastic that nothing can stick to. It'll wash off the moulding with warm water later.

3 A last wipe of PVA as a release agent, and our new mould is ready to go. All we need now is a well-ventilated area, preferably out of direct sunlight, and we can start the lay-up procedure.

GRP hand-laminating

GRP hand-laminating with polyester resin is an easy way to make tough, durable items for your boat. Here Jake Kavanagh explains the laying-up procedure – first working with gelcoat, then resin and glassfibre cloth

As we've seen in the preceding pages, creating a mould for making a glassfibre anchor locker takes time because it needs to be blemish-free if you're to get a professional-looking final moulding. But with the construction, filling, sanding, painting and waxing of the mould complete, we're now ready to start laminating.

MATERIALS:

- Polyester resin
- Catalyst
- Chopped strand mat (CSM)
- Containers for mixing
- Cheap, disposable paintbrushes
- Mixing sticks
- Measuring jugs
- Small, accurate measuring containers – syringes or small pot – for catalyst
- Small roller to help consolidate the new lay-up
- Acetone, for washing brushes and rollers

Glassfibre lay-up materials are available from specialised GRP suppliers, or from a well-stocked chandlery. There are savings to be made with large orders, or buying direct via the Internet. Check PBO's regular classified ads for a selection of suppliers.

TOP TIP

Marked-up recycled food containers make great measuring and mixing pots.

Getting started

You'll need a place to laminate – it can be done outside on dry days, but temperature plays a big factor in the curing rates. Too hot, and it can go off in minutes. Gelcoat can also be affected by a stiff breeze, which can lead to undercuring.

A well-ventilated workshop away from direct sunlight is the ideal.

Wear safety goggles when handling resin, as the catalyst is an organic peroxide – nasty stuff. Also, have a source of saline eyewash handy, so you can rinse your eyes for a recommended 10 minutes if necessary. Hands can be protected by a barrier cream, or with latex or vinyl gloves. Many professional laminators prefer heavy-duty washing-up gloves that can be reused many times.

You can enjoy working with GRP – it's versatile and quick-drying, and the only drawback is the pungent smell of styrene (although appropriate face masks are available from DIY superstores for around £20).

STEP 1 Applying the gelcoat

Moulding with glassfibre involves starting with the 'final' coat first, then working backwards through subsequent layers of resin and reinforcement. The first job – and one with a time limit – is to paint on the two layers of gelcoat that will form the shiny outer layer of our moulding

1 I carefully measured a quantity of gelcoat into one of my pre-calibrated food containers (measuring pots are also available from chandlers, costing around £1). I estimated I'd need around 250ml for a coverage of 1m², but it's better to underestimate and have to mix more than be left with too much, which is wasteful.

2 For the 250ml pot of gelcoat, I needed to measure out two per cent by volume of catalyst, which was done with a small, calibrated beaker. Treat the catalyst with great respect, and always wear goggles.

3 With the 5ml of catalyst poured onto the gelcoat it was then mixed in well, scooping the bottom material onto the top, and stirring gently to avoid spillage.

4 The gelcoat is now active, and has a pot life of around 30 minutes at room temperature. Using a brush, liberally apply the gelcoat to the mould. You're looking to put down a layer of about the thickness of a business card (0.25mm), but too thick is probably better than too thin. And you're not painting, so there's no need to worry about brush marks. With everything covered, paying special attention to the edges and corners, the gelcoat can now be left to cure. Give it about an hour to do so.

5 Next, apply the 'squeak test'. Don't prod the gelcoat – you may poke through it. Instead, run your finger lightly across the surface to see if it gives a 'squeak'. This slight tackiness is needed for the second coat to adhere properly. In any event, the second coat must go on within 24 hours.

6 Mix up some more gelcoat and apply the second layer, again about 0.25mm thick. Leave this to become tack-dry, testing with the squeak test.

You now have no more than 24 hours to get the first layer of reinforcement applied to your mould, otherwise the gelcoat will have lost its ability to bond properly

7 Cut enough chopped strand mat (CSM) to fully cover the mould, extending slightly over the edges. I found the tacky gelcoat tended to pull a few fibres off the mat when offered up against it – so it's wise to pre-cut the CSM before the mould has been waxed or gelcoated.

NOTE: You may decide to start your lay-up with a layer of glassfibre tissue instead. It's a little easier to apply than CSM, and is certainly an advantage in small moulds, or ones with tight corners. Some laminators prefer to start with tissue as it makes subsequent bonds much easier by soaking up more of the resin.

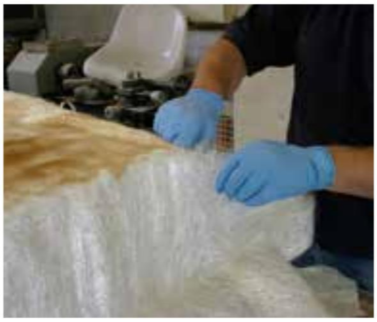
8 Decant some resin. You'll need about two-and-a-half times the weight of resin to the weight of cloth. You can use scales to work out the proportions, but it can also be done by guesstimate. I poured 450ml into an old ice-cream pot, then measured out two per cent of catalyst. The resulting 9ml of catalyst was poured in with a syringe (note the level of the liquid, not the position of the plunger. Don't be tempted to purge the air with a squirt upwards, hospital style – catalyst is dangerous).

➔

STEP 2 Wetting out the CSM

1 I used the 'consolidation' method. Catalysed resin was painted onto the gelcoat, then the dry mat was laid over the top of it.

2 I then applied more resin, working it through the fibres with the brush and following up with a consolidation roller. This forced the resin right through the weave, and as the binding agent of the CSM dissolved with the resin, the whole mat became much easier to work – a bit like wet hair.



3 A top tip for getting the CSM around corners is to tear it. It comes apart easily enough, and the fibres merge back into each other once wetted, avoiding any sharp edges.

4 I diligently went over the whole mould with the consolidation roller, removing the air and making sure that the CSM was the same, uniform brown colour. Any paler areas meant that there wasn't enough resin, so more was added and the roller put to work again.

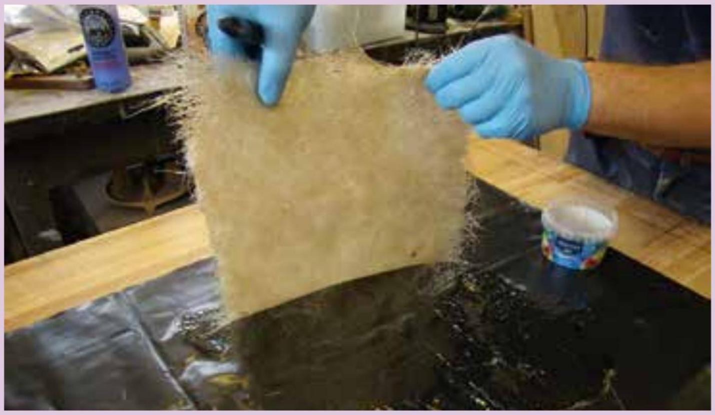
5 The resin cured in about an hour, but as it became tacky I ran a knife along the edges of the mould to cut back the excess. This saves a lot of hard trimming work later. It's known as a 'green' cut, and is easy enough at this stage while the resin has the consistency of thick fudge.

6 With the resin cured, I then ran a sheet of 80-grit (medium-grade) sandpaper over it to rub back the odd fibre or two that was standing proud.

7 Once the gelcoat is covered, extra layers of reinforcement can be laid up at your leisure, depending on how thick you want the moulding. My anchor locker needed to be pretty strong, so I added another two layers of CSM before the final release of the moulding.

TOP TIP Styrene is heavier than air, so the curing process will be accelerated if the fumes can drain out of the mould – perhaps by tipping it onto its side.

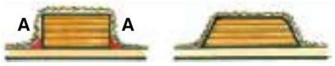
...there is another way



There is another way of saturating the CSM with resin. This involves 'wetting out' on a sheet of polythene. The catalysed resin is liberally stippled onto one side of the CSM, covering the entire area. The CSM can be turned over and stippled again from the other side to ensure the resin has thoroughly soaked in, but it's a delicate and very messy process and bits of the CSM can easily break off. It's better to wet out one side only, then transfer the CSM to the job on the polythene and lay it wet side down on the mould before the polythene is pulled away and disposed of.

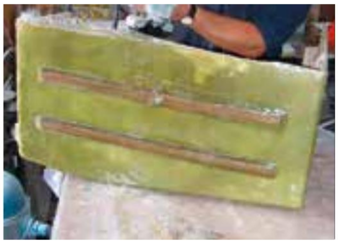
Reinforcement

To stiffen a moulding you can add some strips of reinforcement. This could be plastic piping, plywood battens or special foam which can be easily cut and shaped. The strength comes from the shape of the CSM around the reinforcement material, rather than the material itself.



Square corners (A) can create voids

Make sure the edges of the reinforcement are rounded, to aid the adhesion of the CSM and eliminate voids which could channel water



I glued some rounded strips of plywood in place with a quick-set epoxy before glassing them over with offcuts of CSM

STEP 3 Breaking out the mould

1 With the resin cured (a touch test will tell) this is the time to file or grind back all the edges to expose a clean join between the mould and the moulding. Don't get too carried away or you could damage the finished item.

2 With all the edges exposed, the moulding can now be broken out. First, you need to create a gap between the mould and the moulding, preferably with a wooden wedge. If a gap can't be opened, careful use of a thin blade in a corner will start the split, and the wedges will do the rest.

3 By gradually tapping in the wedges I opened up the mould until, with a sudden rush of air, the moulding came away.

Our mould can be used time and time again

4 And that's all there is to it! Once finished, the moulding is ready to be fitted to the boat. All that remained was to use warm water to wash off the residue of blue PVA mould-release agent.

The PVA proved a little stubborn to remove, and subsequent moulds probably wouldn't need it

Nip osmosis in the bud!

When Rupert Holmes scraped the antifouling off his boat, he discovered some osmotic blisters. Here he explains how he fixed them

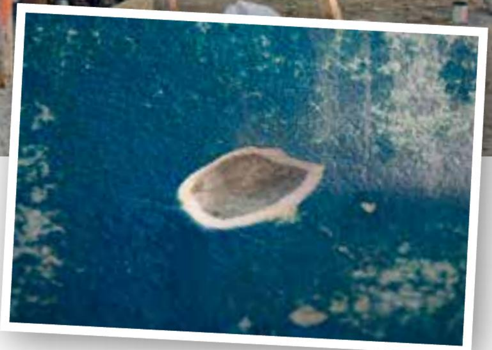
Ammos **in the boatyard in Greece, after Rupert Holmes had scraped off 16 years' worth of antifouling**

The dreaded 'O word' has the potential to spoil any boat owner's day, but fortunately in my case osmosis was not a disaster. In all I found just four small osmotic blisters on the hull of *Ammos*, my Discovery 3000, each a little larger than the size of a fingernail.

Positive identification was easily achieved by testing with the corner of a paint scraper – when pressure was applied the blisters burst, giving off their telltale, acrid vinegary smell, with yellowish liquid seeping out to confirm the diagnosis without a doubt.

As the problem was clearly very limited in its nature I decided to treat each blister individually by removing the affected gelcoat and any damaged laminate, allowing it to dry out thoroughly, and then filling and fairing to reinstate the hull's finish.

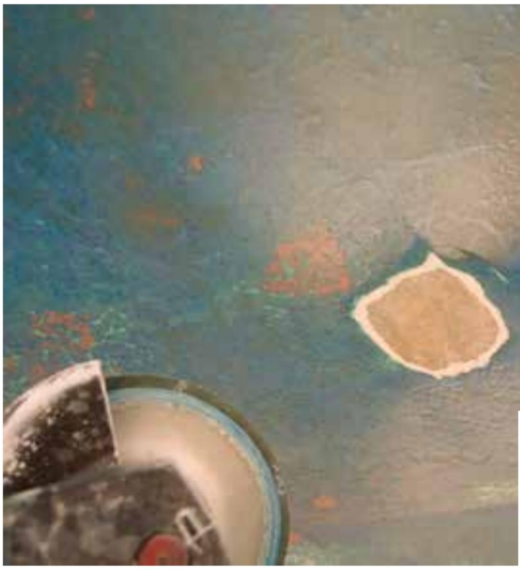
While the hull presented no big problems, the rudder looked like a different matter. I gave up counting after just a couple of dozen blisters on the lower third of one side. It was clear that, at the very least, the entire gelcoat would need to be removed. It's common for spade rudders (apart from the few made of carbon fibre) to have an osmosis problem, even if the hull is sound, largely because it's difficult to create a permanent waterproof seal between the stainless steel shaft and the glassfibre that surrounds it.



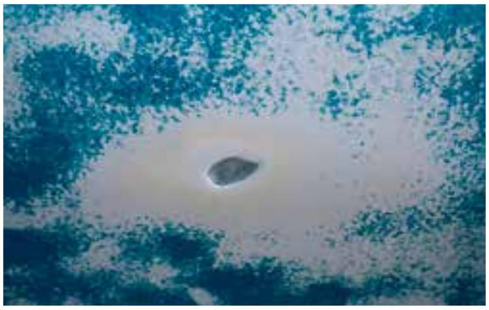
ABOVE This blister had penetrated the laminate and was one of the deepest of those found on the hull

Repairing the hull blisters

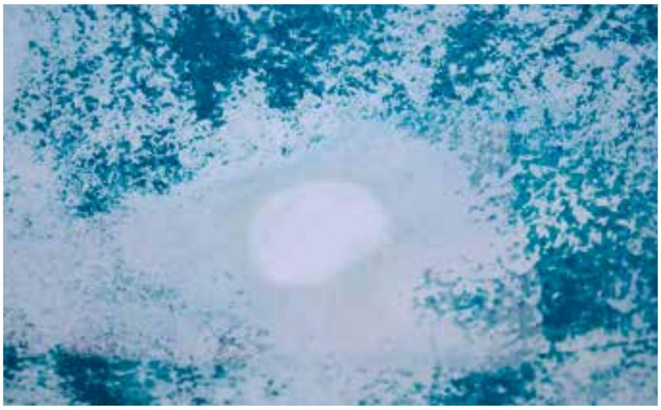
Removing the right amount of material around the hull blisters required a great deal of care as it's easy to dig too deep into the hull with an angle grinder. In this case I only needed to cut into the first couple of millimetres of the laminate – much less than 10% of the thickness of my overbuilt hull. Using an 80-grit sanding disc I cut back a fraction beyond



ABOVE Grinding out a hull blister. To ensure all the damage was revealed I removed an area wider than the visible blister. In retrospect, removing a smaller area of gelcoat and laminate using a Dremel tool or similar would have speeded up the filling and fairing process



One of the blisters after grinding



A hull blister after the first application of filler/fairing mix. A good technique at this stage saves time – less sanding will be required if the damaged area is filled slightly below the final level before applying a second coat of filler

the visible damage, just to be doubly certain that I had removed the entire problem. This turned out to be a worthwhile move as in one case it revealed a further area of delamination, albeit a very small one.

Filling the holes

The next stage was to wash the affected areas thoroughly with water to remove all traces of osmotic fluid, and then allow the hull to dry. Fortuitously the three summer months I left *Ammos* ashore in Greece coincided with a heatwave, and when I returned the moisture meter readings were resolutely at zero. Had I been doing the same job in the UK, the use of infrared lamps would have helped it to dry out.

A mixture of gelcoat and colloidal silica, mixed in proportions to give a meringue-like consistency (ie capable of standing in peaks), was used to fill the holes that had been ground out. The filler needs to be applied sparingly with a flexible spatula that's wider than the hole it's covering. The first application was slightly concave relative to the line of the hull – once set the filler is hard to sand, so it's important not to allow it to stand proud of the surrounding area.

A second application of the same filler mix approximated the hull's curve more closely. After this was sanded smooth I applied a couple of layers of gelcoat by brush. Finally, more sanding with progressively finer grades of paper saw the entire area smooth and fair with the lines of the hull.

Anti-osmosis treatment?

At this stage I debated whether or not to epoxy the hull with an anti-osmosis system such as produced by Blakes and International Paint. In the end I decided that four blisters in a decade-and-a-half is a number I can happily live with and therefore it wasn't worth the time and expense of an epoxy treatment. I won't be too worried if I have to treat the same number of blisters again in five years' time, although I doubt I will find any.

This decision might well have tipped the other way, however, had the boat been in the UK, where drying the hull laminate is both more time-consuming and potentially vastly more expensive.

Ammos resplendent in a fresh coat of antifouling and ready to be relaunched

Repairing the rudder damage

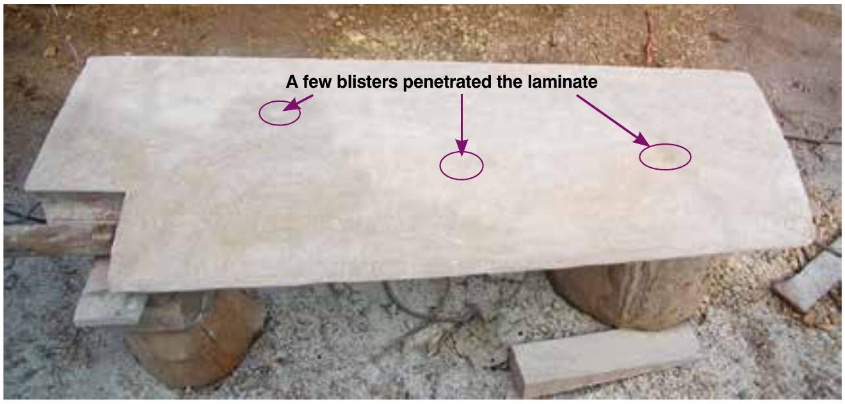
After removing the rudder from the boat I used an angle grinder with coarse, 36-grit discs to strip the entire gelcoat and grind out all of the blisters until solid laminate, free of defects, was reached. I was fortunate in that, although there were many blisters, they were very shallow and only a handful penetrated more than a couple of millimetres into the laminate.

The next stage was to thoroughly wash the foil with water – osmotic fluid is water-soluble, but must be fully removed before the damage is made good. I also drilled holes into the core of the rudder to check whether there was any water trapped inside that may cause serious weakening of the structure, but to my relief it was dry.

As with the hull, the Greek heatwave did an admirable job of drying the laminate, and moisture readings were zero by the time of my return to the boat. Readers who don't have easy access to such an effective drying regime will need to adopt an active drying procedure, but this is easier for a relatively small component than for an entire hull. One method would be to take it home, securely support it in a garage or other suitable space and direct an infrared lamp or heater on each side until the moisture readings reduce to an acceptable level.

Next came another wash with water to ensure no more osmotic fluid had leached out of the laminate, followed by a thorough clean with acetone. After that, a quick sand using 36-grit paper in a random-orbit sander (I used a model with a dust extraction system which made it a relatively clean operation) helped to smooth out the surface of the foil by taking off the highest bumps.

To replace the strength lost through removing some of the top layer of laminate I then added two new layers of chopped strand mat on each side of the foil.



ABOVE The rudder after grinding off the entire gelcoat. Note the small number of blisters penetrating into the laminate – these required additional grinding

Difficult task ahead

The next stage was by far the most skilled part of the whole project: fairing the moulding to a smooth and hydro-dynamically efficient surface. First, I mixed a filler of gelcoat and colloidal silica – again, the relative quantities are correct when the filler will stand in peaks, just as when making a meringue.

I applied this sparingly with a wide trowel to fill the troughs and dips in the surface. Don't be tempted to use too much: it's easier to apply more at a later stage than sand off too much, and doing so risks losing the original line of the moulding. Once cured, I sanded the foil to profile with the random orbit sander using 80-grit paper, and then again with 120-grit paper.

All that remained then was to reapply the gelcoat. I did this using a small roller, building up a number of coats until a thickness of around 1mm was achieved. Finally, it was machine-sanded again using progressively finer paper to give a smooth finish akin to one that's achieved in a mould.

The rudder after the first application of gelcoat/colloidal silica fairing mix. Next it was machine-sanded with coarse paper, before a second application of the fairing mix

The fairing stage complete, with the rudder ready to be gelcoated. This was applied with a roller in a number of coats to build up thickness, then sanded with progressively finer grades of paper to produce a fair and smooth final finish

The repaired rudder in place and ready for antifouling

Even extensive damage like this can be repaired with DIY materials if you have the patience

Learn how to repair this hole on page 111

Repairing holes in GRP

If you need to plug a hole in your glassfibre boat, fear not – repairs are easy to make. Jake Kavanagh shows how it's done and offers some useful tips

One of the beauties of glassfibre boats is that they are so easy to fix. Even a hole the size of a domestic fridge can be invisibly repaired, and the hull will be just as strong as it was before (or even stronger). Nor do these repairs involve rocket science – just some manual dexterity and the ability to think in three dimensions.

Repairs become more difficult when the damaged area is largely inaccessible, or on an awkward corner. And unfortunately, unless you intend to paint over the repair, colour-matching the gelcoat is a real challenge, and a job best left for the professionals.

But for our purposes we're going to look at filling and fairing two gashes – one simple, one awkward – so they sand back smooth.

Resins

There are two main types of resin available for repairs: epoxy and polyester.

All the repairs mentioned here can be done using either one, but as we were attending the advanced repair course run by Wessex Resins, the UK distributor of the West System Epoxy, we worked entirely with their products.

Polyester

Nearly all GRP production boats are made from polyester resin, which is about a quarter of the price of epoxy. Supplied as 'pre-accelerated', it usually has a one-year shelf life, and to start the curing process you simply mix in a small amount of catalyst. The downside is that polyester resin shrinks as it cures by as much

Pump kits make mixing easy

as 4%, which can put strain on a repair, and it will repair only a quarter of the area compared to the equivalent amount of epoxy. Its adhesive qualities, especially to wood, are not exactly brilliant and it has a pungent aroma. That said, it is easy to use, cheap and effective.

Epoxy

Epoxy, on the other hand, is probably more suited to repairs, which need to be light, strong, and involve bonding to other materials. It has minimal shrinkage, and is a powerful adhesive. The resin has to be mixed in precise amounts with the hardener, and mistakes can weaken the mixture. The downside is the price, and the fact that it is quite sensitive to temperature when curing. The process almost stops below 5°C, but hardens in minutes if it's too hot (unless tropical hardeners are used). It is incredibly tough, with virtually no smell, and is remarkably versatile.

Peel-ply

Once epoxy has cured, it leaves a shiny surface that has to be abraded before anything will stick to it. An answer to this is to roll down a layer of peel-ply, which is made from nylon. The peel-ply is simply torn away once the epoxy has cured (it is too slippery to be bonded) leaving a roughened surface, ideal for further sticking jobs.

Safety tips

When using either polyester resin or epoxy, make sure you cover up well. Always wear gloves and, if rolling resin, then goggles are also advisable. Epoxy can cause dermatitis if in contact with sensitive skin; although with modern formulas this risk has been drastically reduced.

Reinforcement

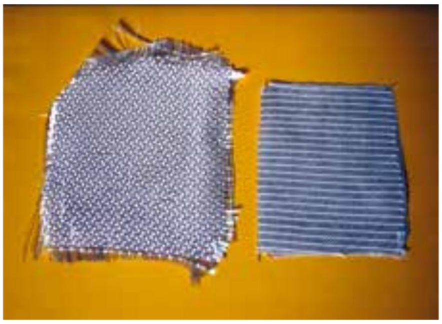
The strength of a repair comes from the reinforcing cloth behind it, and there are three main types:

1. Chopped strand mat (CSM)

Made up of two layers of 50mm chopped strands of glass held together in a styrene binder, CSM is designed to spread loads in all directions, and once the polyester resin soaks in, the binder is dissolved by the styrene. This means it can't be used with epoxy, which is styrene-free. The binder remains intact, which builds a weakness into the structure.

2. Woven roving

These are long strands of glass woven into a cloth that makes it strong and able to hinge without breaking up. It is ideal for use with all resins.



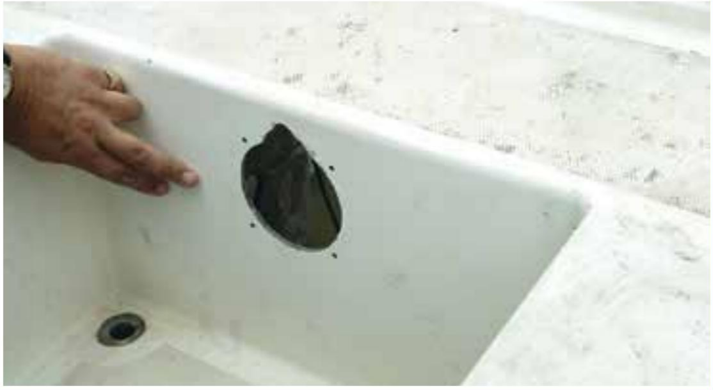
Woven roving (left) is a versatile cloth, but stitched cloth (right) is stronger...

...and can also be manipulated into tight shapes with no loss of cohesion

3. Stitched (engineered) cloth

Probably the best (and most expensive) material to work with, as it is particularly strong, and can be manipulated into very tight shapes.

Gaining access



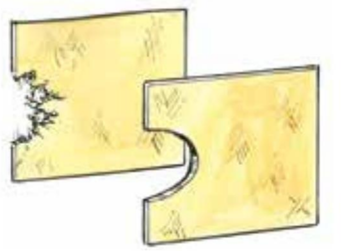
A successful repair will depend on the degree of access to the hull. Broadly speaking, there are repairs that you can get to from both sides of the hull, and those you can only tackle from the outside. Where access is limited, you need to take extra care to get a good bond.

Holes in the gel coat don't always have to be accidental. You may have moved a bilge pump or bulkhead-mounted compass, for example, and simply want to fill the hole that's left.

Turn over and we'll show you how to repair the hole pictured above.

Repairing accessible damage

Damage: Hole **Surface:** Flat **Access:** From the inside and outside



1 If the hole has been smashed in, it can be cut around with a fine-toothed jigsaw blade. If it is a pre-cut hole, you may still need to trim it up with a Dremel to remove any cracked or flaked gel coat.

2 Grind out a shallow depression behind the hole to a ratio of about 12:1. An angle grinder with a coarse (40-grit) disc will make short work of this.

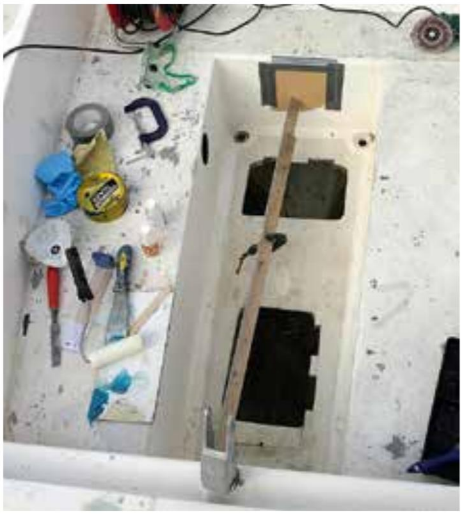
3 If room is limited, as at the top here, make the depression as shallow as you can.

4 Stick a piece of thick polythene over the hole on the inside, and draw a series of decreasing circles on the depression, up to the edge of the hole itself. These will be cutting guides for the fabric circles. The number of circles will depend on the thickness of the structure. The thicker it is, the more you will need. Mark the orientation of the polythene, so you know which way up it goes.

5 Remove the polythene, and use it as a cutting guide for the stitched or woven fabric. Here is a good chance to use up any offcuts or scraps (but don't use CSM).

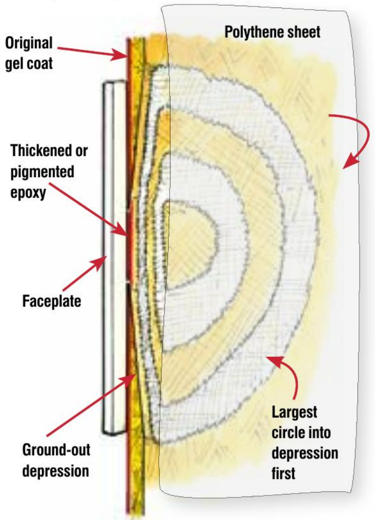
6 You will now have around four or five circles of fabric ready for laminating.

7 Lay up the repair against a blanking plate, which can be any slippery surface cut not much bigger than the size of the hole. We're using a piece of white-coated hardboard. Three layers of release wax are rubbed onto the inside surface, avoiding lumps and smears.



8 Push the blanking plate up against the hole and secure it. In this case we used duct-tape, and held it firmly in place with a compression post.

The principle of the repair


Original gel coat
Polythene sheet
Thickened or pigmented epoxy
Faceplate
Ground-out depression
Largest circle into depression first

9 Fabric circles will be filling the depression to make it flush on both the inside and outside of the hull. Contrary to what you would expect, the largest circle will be the first into the hole, to make maximum contact with the lip of the depression. It will sit on a layer of thickened epoxy.

10 Mix up some thickened or pigmented epoxy (ordinary epoxy with some silica powder added) and paint it liberally onto the inside of the hole, so it covers all the depression and the faceplate. Brush carefully in order to avoid any air bubbles.

11 Now place the polythene guide on the work table, and lay a fresh polythene sheet over the top so the guide marks show through. Mix up some epoxy, and smear it onto the polythene.

12 Place the smallest circle of fabric into the centre of the guide first, and then wet it out with epoxy. Try not to use too much.

13 Once wetted, place the second-smallest circle directly on top, staying within the guidelines, and wet out. Just keep going like this until all the circles have been laid one on top of the other. The biggest one will be last, and will be pressed against the hole itself.

14 Mark the orientation on the polythene, and then pick it up. By now, the thickened epoxy painted onto the repair in stage 10 will be going tacky, which will hold the plug in place.

15 Using the polythene as an applicator, firmly press the plug onto the middle of the hole. If you have used the epoxy sparingly, it shouldn't slump.

16 Peel away the polythene, and give the repair a last pass with a roller to drive out any trapped air. Leave to cure.

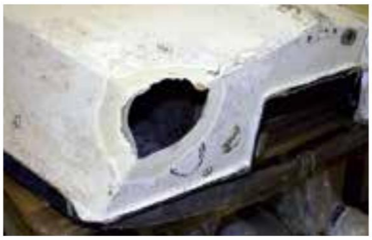
17 Once the repair has fully cured (usually a few hours, depending on temperature) the tape can be removed and the faceplate carefully pulled away. The epoxy should have formed a new surface flush with the old one. The repair can now be lightly abraded and then painted with an epoxy primer. Note: oil paints do not seem to harden over fresh epoxy, so use an epoxy primer first.

A short-cut for small repairs

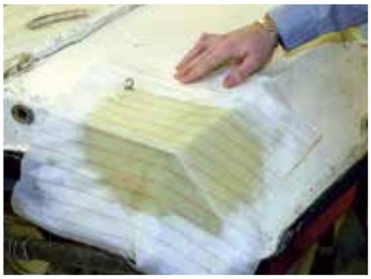
A labour-saving short-cut is simply to use the blanking sheet as normal, and put down a layer of thickened epoxy behind it in place of the circles of cloth. The repair can then be consolidated with an overlapping patch of reinforcing cloth. This method works well enough on small holes, such as this 19mm (¾in) pump outlet. Any imperfections are made good with filler on the outside before painting. It's not as neat, and may not be as strong, but will serve the purpose.

Repairing inaccessible damage

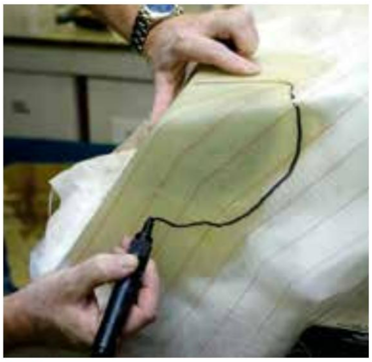
Damage: Hole **Surface:** Awkward corner **Access:** From the outside only



1 The corner of this dinghy has been taken off by a collision, but being a sealed buoyancy tank, it was impossible to access from the inside. Somehow, we had to get a backing plate behind the hole so we could build up against it. If an undamaged part of the boat matches the damaged area, it can be used as a mould for just such a backing plate. Firstly, the outer surface is cut back to make a shallow depression. The inside edges of the hole are also abraded and wiped with epoxy.



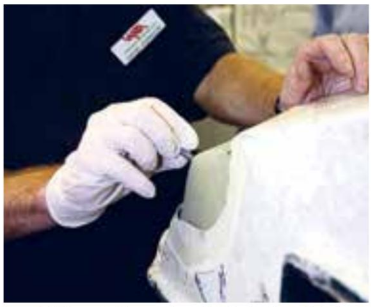
2 The undamaged starboard corner was a close enough match to make a mould from. (Better still, a dinghy from the same class could be used for a perfect mould.) The corner was coated with release wax, and then a layer of reinforcing cloth was laid over the top. It was taped down to create the shape, and then coated with activated epoxy. A sheet of peel-ply is placed over the top to give a roughened surface.



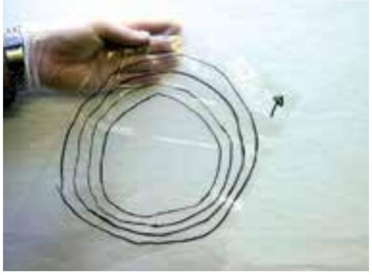
3 Once cured, the mould is transferred to the damaged area, and positioned over the hole. A pen line is marked around the damage, allowing about an inch of overlap. (The hole can be clearly seen through the cloth.)

4 The mould is removed, the peel-ply pulled away, and the excess material removed with a bandsaw (you could use industrial scissors or a cutting disc).

5 A screw is inserted into the central part of the backing plate, and the inside edges are then coated with five-minute epoxy.



6 Although bigger than the hole, the plate is flexible enough to be inserted behind it and orientated to the correct position. It is then pulled back against the hull using the screw, allowing the five-minute epoxy to take hold. Now tacked into place, the backing plate gives a surface on which to build a repair. The inevitable gaps can be filled with some epoxy thickened with a filling powder.



7 The building up of the hull is simply a re-run of the 'ever-decreasing circles' method. A polythene tracing sheet is laid over the depression, and a series of circles drawn on. These allow the sheets of cloth to be cut out, and then stuck down on the polythene. Once again, the smallest circle is stuck first, and the largest last. The sheet has to be marked for orientation.

8 The sandwich is laid on to the hull and smoothed into place.

9 The polythene is removed, and a roller is used to smooth it all out. Once cured, the repair will have effectively rebuilt the hull thickness. The final stage is to smooth the repair over with a sandable filler, building the filler slightly proud. Using an orbital sander, this is then taken back until absolutely flush. The repair can then be painted.

Gelcoat repair

Everything you need to know, from preparation and filling to topcoat and polish

STEP 1 Preparation and matching the colour

The first job is to check the damage closely, both inside and out. Sometimes a hard knock can cause delamination within the hull, in which case a more serious repair will need to be carried out first.

In this example damage to the hull at the stem is fairly typical of a modest dockside shunt, and proved to be cosmetic rather than structural.

If the edges hadn't been sharp we'd have first had to remove any loose material with a Skarsten scraper. As it is, in this case we can simply give the damage and the surrounding area a good wipe over with acetone to remove any wax or dirt.

Before any repair is made you need to know the true colour of the hull – there's no point matching a repair to a faded pigment which will change when it's polished. Ideally, then, you need to polish the hull back to as close to its original colour as possible. Chalking and superficial scratches had already been polished out of our example boat's hull, so we had a true colour to work to. If it had been an untreated hull we'd have needed to prepare a small area first.

1 **First choose a part of the hull identical in colour to the damaged area. This will become the mixing palette on which to colour-match the gelcoat. Go over the area with 1,000-grit abrasive paper to remove scratches and chalking.**

2 **Using a rubbing compound, the area is then flatted to restore the original colour of the gelcoat, leaving it with a slightly matt finish.**

3 **Enough plain white pigment is decanted to complete the entire repair. A small amount will be placed onto the prepared palette area.**

4 **The hull may appear white, but look closely to see what colour tints might be necessary for a perfect match – in this case a hint of green, with a trace of yellow and a touch of cream.**

5 **Using a mixing stick, place a few dabs of uncatalysed white gelcoat onto the hull. These will become your testers (because they haven't been activated with catalyst, they can later be wiped off with acetone).**

6 **Now for the tricky bit. A tiny dab of the dominant colour is placed on the end of a cocktail stick…**

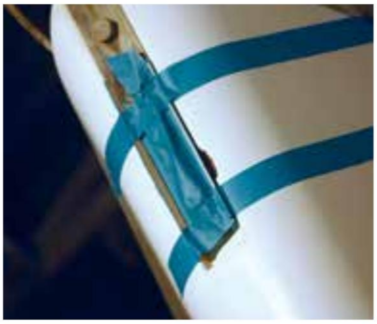
7 **… and is then mixed into the tester. Care is needed to ensure all the pigment is evenly distributed, which requires some dexterity.**

8 **When you are confident you have the green element of the match, you can then switch to the next colour, cream, and repeat the process. If the match goes wrong, start again.**

9 **Throughout the process, keep a mental note of how much of each pigment you have used for the match. When you're happy with the result, use this experience to multiply the ratios to make a full batch of gelcoat, enough to complete the whole repair.**

STEP 2 Filling the hole

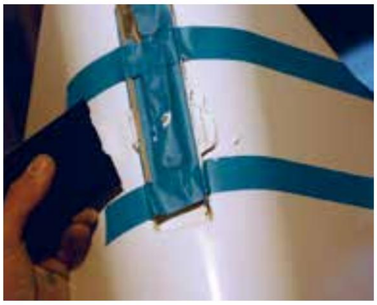
Once mixed, the colour-matched batch is then split, with some being kept back for the finishing coat. The majority will be used for the initial fill, and here a filler powder is added to bulk out the gelcoat so it stays put, making sure the colour remains the same. As a check, it can be dabbed back onto the hull at any stage. It's important that the entire repair is colour-matched and not just the surface layer. That way if the hull is abraded back any time in the future, the repair will remain invisible.



1 The repair site on the stem is masked off to protect the stainless steel strap. Note strips of cardboard used to make small cofferdams.

2 The thickened mix then receives some catalyst at a ratio of 1%. It's important not to add any more than this to hasten the cure. The heat generated by a fast cure can actually alter the colours, making them darker.

3 The colour-matched filler is then thoroughly stirred together to make sure all the catalyst is mixed in…



4 …before being applied firmly to the holes with a flat scraper. The excess is then taken off with the scraper's leading edge until the filler is standing just slightly proud.

5 Once fully cured, the area is then sanded back flat with 240-grit paper on a sanding block. Using a block is best as pressure from fingertips and sandpaper alone can sometimes produce an uneven finish.

6 With the area flatted, it can then be tidied as shown here, making the edge of the repair smooth. The masking tape stays on the stainless strap to protect it from scratches.

7 The next job is to go over the repair with a random-orbit sander fitted with a 400-grit disc. This will match the final blend of the filler to the rest of the hull, and give a super-smooth surface for the last stages.

STEP 3 Applying the topcoat

The critical stage is to apply the topcoat. This is our last batch of colour-matched gelcoat, and it is unthickened. The addition of a little wax-in-styrene (2%) before the catalyst is added will slightly improve the flow, and make the curing easier.

1 A 2% addition of wax-in-styrene is mixed into the final batch of gelcoat. It is stirred well, and then the catalyst is added.

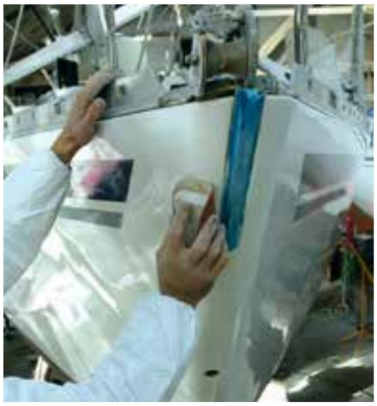
2 Now gently paint your activated gelcoat over the whole repair, avoiding brush marks and making sure you get a fairly wide coverage.

3 Once the topcoat has dried, usually in about an hour, the masking tape can be removed. The surface is given a wipe down with acetone to remove the wax, and also any splashes that may have got under the tape. The metal is colder than the hull, so gelcoat splashes on it might still be quite soft and easy to remove.

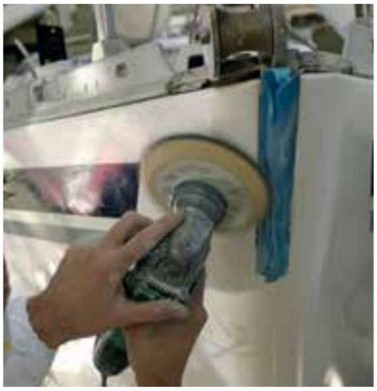
STEP 4

Final polishing

The topcoat can now be fully blended into the surrounding hull. You'll achieve this with some very fine abrasives, followed by a polishing process.



1 Using a sanding block again, a 400-grit paper gently flattens off the topcoat, not forgetting details such as the edges around the strap.



2 Switching to a finer 800-grit paper, the repair is now machine-sanded, paying attention to the stippled edges. Everything is done in short bursts, and with great care.

3 The final stage is with a 3,000-grit abrasive disc. This can bring out a perfect shine by itself – but one final stage is yet to come.

4 Polishing compound is now applied with a brush. Adding a little solvent to the mix makes the polishing compound smoother and workable for longer.

5 Using a lambswool buffing head on a slow-running rotary polisher, the repair is given a final polish to really bring out the shine.

6 JOB DONE. A layer of UV protective wax can now be applied to protect the hull – and its invisible repair – from UV fading.

TOP TIPS

■ The catalysed gelcoat will set in about 30 minutes, but the cure could be accelerated by heat from the hand. If you don't want this to happen, hold the mixing pot by the rim.

■ Once the wax and catalyst have been thoroughly mixed, tap the container a few times on the worktop and let it stand for a few seconds. This allows any air bubbles to make their way to the surface. Bubbles trapped during application will leave pinprick voids in the finish.

■ Use the brush to stipple around the edges of the topcoat. This will give you a seamless merging of the gelcoat with the surrounding hull when it has been sanded back.

Coloured hulls

This repair has been to a 'white' hull, but exactly the same principles apply to pigmented hulls. The only major difference in that case is that you would use a clear gelcoat to carry the deep colours required, rather than a white one. To bulk out a clear coat, a colloidal silica would be used instead of the filler powder we used for this job.

Thanks

Our thanks to Aaron Logan of Small Boat Services, **www.smallboatservices.co.uk**

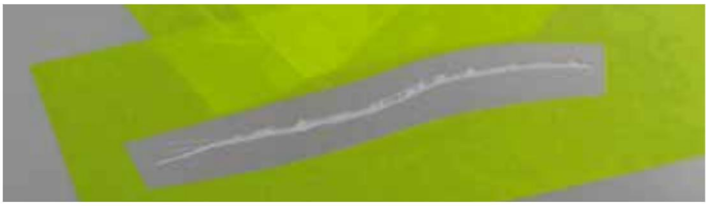
Thanks also to Hayling Yacht Company for the loan of their shed, **www.haylingyacht.co.uk**

Colour matching the quick way

A basic colour match may not be perfect – but in most cases it'll do the job

If your boat has a pigmented hull, it is possible to get a fairly close match using clear gelcoat and a bottle of pigment. Chandlers will sell a range of small pots of colour designed to replicate the most popular (unfaded) shades.

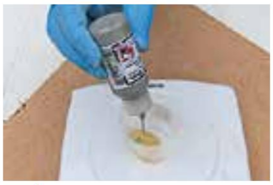
The pigment is mixed into the gelcoat before the catalyst is added, so it can be compared against the hull nearest the damage. For the very best results, use a polishing compound on the damaged area of the hull first, to remove oxidation and get to the true underlying colour.



1 As with the previous repair, the damage is tidied with a blade, cleaned with acetone, and the area around it masked off.

2 A small amount of clear gelcoat – more than enough to fill the repair – is decanted into a calibrated beaker…

3 …and then placed onto some digital scales (these improve accuracy when mixing in a ratio of catalyst). If you don't have scales you can make a 'guesstimate' based on volume instead.



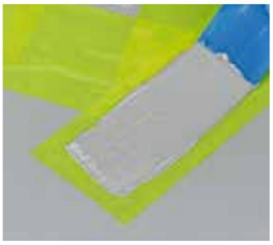
4 Using a bottle of grey pigment, which seems pretty close to our boat colour, we measure out no more than 10% by weight – or volume – using a graduated beaker.

5 The pigment is thoroughly mixed in, and then wax-in-styrene is added to a ratio of 5%. A small syringe will be useful here.

NOTE: The wax rises to the surface of the gelcoat, excluding air (necessary to allow the gelcoat to cure properly underneath). It is also possible to use a spray wax coating over the gelcoat instead, or some repairs can even be done by taping airtight film over the top.

6 To bulk out the gelcoat and stop it running out of the gouge, you can add fine silica powder. Wear a mask – the powder is carcinogenic.

7 When ready to proceed, just add catalyst at a ratio of 2% and mix together thoroughly.



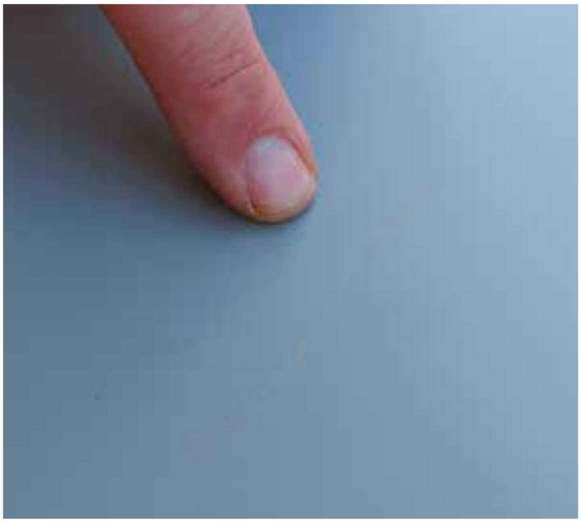
8 Work the paste into the hole using a plastic applicator.

9 Once cured, the repair should be standing slightly proud of the surrounding area...

10 ...so it can be sanded with 400-grit paper until flush with the rest of the gelcoat.

11 Then sand lightly again with an 800-grit abrasive to restore the smooth surface.

12 Finally, give the whole area a buff with a cutting compound/ gel restorer to bring back the shine.



13 While not as perfect as a professional colour-matched repair, this scratch will be still be hard to detect from a distance.

How to... CHECK YOUR RIGGING

Maintenance of your rigging can save expensive failures and could be a lifesaver, advises Ben Meakins

'The first time most people realise something is wrong with their rig is when something breaks,' says Dennis Fisher of Advanced Rigging & Hydraulics. Keeping your rigging in good condition can be a lifesaver, but it can be hard to know when to replace the standing rigging, and to know what to look for before you start the season to ensure your rig stays up throughout the year.

'Think of a rig as a coat hanger,' says Dennis. 'You can repeatedly bend a coat hanger vigorously and it'll break quickly, or you can work it slowly for a long time – but it will still break. Standing rigging is the same. Even if your boat has been hardly used for 10 years, it will still have the potential for something to break when you least expect it.'

Insurance companies generally recommend that you replace your standing rigging after 10 years – and most riggers agree that this is a reasonable life expectancy. 'It's impossible to tell exactly how long rigging will last,' says Dennis, 'but there's a lot you can do to ensure you spot any problems early enough.'

So what preventative maintenance should you carry out to ensure your rig will last as long as possible?

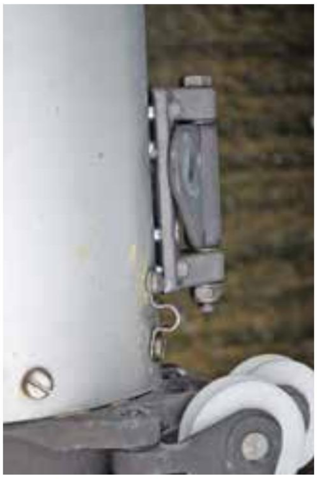
TOP TIP

If you've found any black water stains (aluminium oxide and water) on deck, that's a sign that something is wearing or moving that shouldn't be – time to investigate!

Walk the deck

'The first area we check is the gooseneck,' says Dennis. Check that any fittings are securely riveted on and have no movement. Gooseneck pins shouldn't be bent, and toggles should only move as they're supposed to move. Pack them with washers – nylon ones are cheap, and effective at packing out gaps – to stop any vertical movement.

☐ Check the boom's fittings, especially the kicker attachment, for movement. Ensure that any riveted fittings of dissimilar metals use a jointing paste like Duralac to keep them separate. 'We often see fittings that look fine from the top, but when we take them off the mast wall underneath looks like the surface of the moon,' says Dennis.



Check the boom's fittings for any movement

☐ Check the mast foot for corrosion, movement and cracks. 'This takes the biggest compression loads of the whole rig,' Dennis advises, so it's important it is secure. Also, check the T-bar that the mast sits on for any damage, and replace if necessary.

☐ Your roller-furling gear should be easy to use: if it's difficult, inspect and service the drum. It has been known for the rotation load on a stuck drum to unwind a compression terminal, which could lead to the loss of a rig. Flush it with a hose to free it from salt, then keep it moving with a dry silicone lubricant.

☐ Sheaves should turn – and if they stop turning, they will begin to wear, which means they'll never move again. Free and lubricate any stuck sheaves: a kettle-full of hot water is ideal for this. If in doubt, drive out their retaining pins and check all the bearing surfaces.

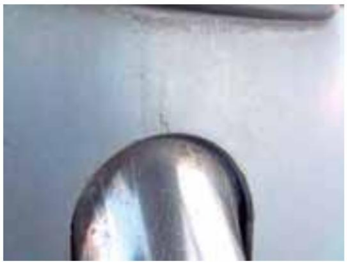
☐ U-bolts and shackles can wear on each other, leading to damage and potential failure – so check regularly. It's also worth tightening up shackle pins and mousing them with a plastic cable tie or Monel wire to keep them secure.

☐ SSB backstay insulators are plastic and degrade in UV light, so it's worth replacing them in line with the manufacturer's instructions. 'There's no way of knowing when they will fail,' says Dennis, 'so all you can do is follow the instructions.'

Checks to do up the rig, or when the mast is down

Bottlescrews should be able to move and should be free from cracks and discolouration. Never force a bottlescrew as you run the risk of stripping the thread. Instead, leave some penetrating oil to seep in first.

☐ Check the mast wall for cracking or deformation around T-terminals and other fittings. A crack will show that something is bearing where it shouldn't.



☐ Check that any rigging wires are in column throughout their length, especially where they enter an end fitting. If there's a bend or the wire doesn't line up with the end fitting, you may have a problem.

Swaged end fittings are particularly prone to breaking – 'the wire tends to go just inside the fitting, where the rig's movement chafes it against the harder end fitting', says Dennis. With the mast down, flex and bend the end fitting, checking for broken strands and any movement.

☐ Check split pins are in place. The pros use a blob of silicone instead of tape over the bent ends to cover the sharp edges. But, says Dennis, this creates a mini greenhouse effect which can, over time, become an ideal environment for encouraging corrosion.

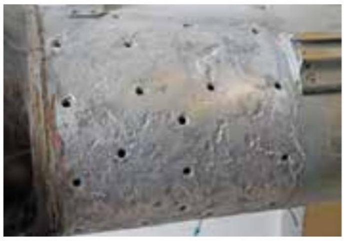
☐ **SPREADERS:** Check for cracking, corrosion or any movement. If a running backstay or spare forestay has been rubbing along the spreader, check it hasn't worn through the casting. 'These can cut through into the hollow spar,' says Dennis, 'and damage them, so check carefully.'

TOP TIP

By lying on the foredeck to steady yourself, you can check the masthead and other fittings with binoculars. It can save you a trip up aloft.

☐ **ROD RIGGING:** The rigging is designed to move within its end fittings, collars and backing plates – and these need lubricating to ensure they can move freely.

☐ **ELECTRICS:** A loose electrical connection can set up a nasty bit of galvanic corrosion, with masts literally being eaten away – so check all contacts and wires to make sure they're not leaching current.



Regular checks

These checks should ensure that you spot any problems before they develop into anything more serious. Regular checks and preventative maintenance are the key – but if there's anything that you're unsure about, head for your nearest professional rigger and ask their advice. PBO

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Upgrading deck gear

Ben Meakins outlines what gear is available and offers valuable tips and hints for the best ways to install it

There are few things more satisfying than a well-set-up boat with sheets and control lines that work smoothly.

That said, it's surprising that so many boats are a struggle to sail – with their halyards wrapped around ancient cleats, friction thwarting you at every turn, and winches that are undersized or that have lost their grip.

The problem is that when it comes to upgrading any deck gear, the choice is vast. Chandlery shelves groan under the weight of Seldén, Barton, Spinlock, Harken, Lewmar and every other manufacturer of deck gear, and choosing what to buy can be a minefield. On the next few pages this guide aims to give you an idea of what's out there and expected for each application.

Leading lines aft

Traditionally, boats had uncluttered decks, with winches mounted on the mast and halyards kept coiled alongside. This is all well and good, but makes adjustment tricky and means you have to leave the cockpit to shorten sail – something most people are reluctant to do in a rising gale.

One solution, as seen on many modern boats, is to lead the lines aft to clutches on the coachroof. This has the advantage of making them far easier to adjust, which will improve your sail trim no end.

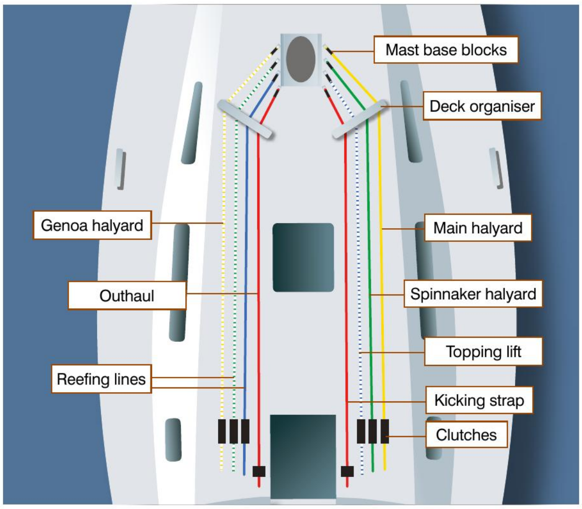
Which lines to lead aft

It's a good idea to draw up a diagram of your boat's coachroof layout, with the lines that you want to lead aft.

Among those most often led aft are: outhaul, pole downhaul and uphaul, reefing lines, topping lift, main halyard, kicking strap, genoa halyard and spinnaker halyard.

Where they come out of the mast or boom

Where the lines exit the mast determines which side you can lead them back to, and which side the blocks at the foot of the mast will need to be situated. If one side is over-represented, consider leading the lines from the boom all down one side to balance it. Another thing to consider is where lines that will need adjustment together end up – for example, reefing lines and main halyard, which you'll need to ease and tension simultaneously – so it pays to lead them to different sides so you can use two winches.



Drawing a diagram of your deck will help you to plan good leads from the foot of the mast via organisers to your clutches and winches

Cheek/turning blocks

Once you know how many lines you'd like to lead aft, you can work out how many cheek blocks you need, and where they should be placed. When you're siting them, remember that they will need to be bolted through the deck with a good backing pad to spread the load – so be aware of bulkheads and interior fittings when you consider where to site them. You can either go for single upright blocks, or else something like Barton's multiple block base, called a mast base organiser.

Organisers

Further back from the mast you'll need something to run the lines through. A deck organiser is what you're looking for. These are available in sizes from two to eight sheaves, and you can stack them on top of each other if necessary. Your boat's coachroof will affect where you site the various items of deck hardware. Some older boats have 'stepped' coachroofs, and here you may need to be inventive, either mounting the blocks high enough to avoid the 'step' or installing stainless steel rubbing strakes to counter chafe. If you've got a big moulding to get around, Barton offer upright blocks to lead lines over and around obstacles.

Clutches

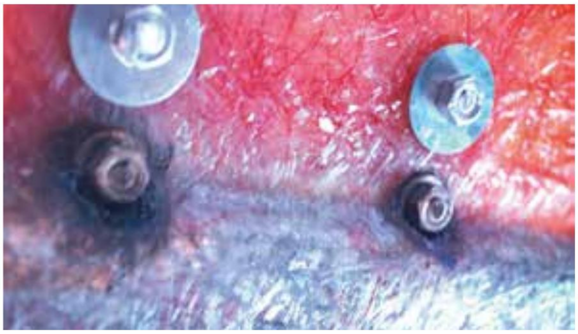
Finally, your ropes will need somewhere to make them off. As a general rule, if you will be tensioning the line with a winch, you'll need a clutch: if not, then a cleat will do. A basic cam-cleat will suffice for lightly-loaded lines and will save you some money, but many boats use clutches for everything as they are quick and simple to use, and release ropes easily. You can buy them in banks of up to four.

Clutches should be nearly in line with the halyard winch, so that when you grind on a line it is deflected from the clutch by no more than about 5°, or else you'll risk wearing the line and clutch unnecessarily. For more on clutches, see page 121.

You can buy clutches singly, or in banks of up to four

Installing deck gear

So you've drawn up your diagram, and it's time to start drilling holes. But before you start, consider the following:



Interior mouldings

On boats with separate, interior mouldings, it can be impossible to get at the underside of the deck moulding without using a holesaw to gain access. If this is the case, you'll then need to cap the hole to keep it all looking smart. Watch out for wires, old fittings and bulkheads when you're positioning fittings. There's nothing worse than trying to get a nut on when you're right up against a bulkhead.

Backing plates

If the deck layup is particularly thin, you'll need a good-sized backing plate to spread the load. At the very least, use large penny washers to stop them pulling through the deck. Mast foot blocks definitely need a big backing plate, as the load is generally an upward force.

Sealant

Any marine sealant will do – but an adhesive one, such as Sikaflex, will give you the best seal. The important area to concentrate on is around each screw hole – and it's good to gun it around the edge of the fitting, too. It should bead out a little from the sides, which can be faired with a gloved finger. Bear in mind that some winch bases, for example, have dedicated water drain-off channels, so avoid blocking these with sealant or your winch bases will corrode away.

Bolts

Use the thickest bolt that will fit in the deck fitting, but don't use an overlong bolt if you can help it – you'll just have miles of thread to do up. Ensure you tighten the bolts evenly.

Old sealant

If you're replacing an old fitting, it's important to clean the existing sealant off before applying new. A scraper – particularly those designed for taking paint off glass – followed by a scourer is good for this, with a final clean-up with white spirit before you apply the new stuff.

Fitting jib cars

On many boats, especially those with the tracks mounted on the toerail, the track will need to be curved. Some manufacturers, like Harken, will bend a track to your specification. If money is tight, you can persuade a straight track to take up a small bend by fixing the ends first and, bolt by bolt, encouraging it to take up the bend.

Don't skimp on the fixings. Jib cars experience very high loads, with the force taken in a near-vertical pull, so use the thickest diameter bolts available, with large penny washers to spread the load. Some ball-bearing tracks use sliding-head captive bolts, which can be a pain to line up correctly – it's worth taping them in vaguely the right position, and dry-fitting the track to ensure all the holes line up.

Clutch or cleat?

When it comes to choosing a clutch or cleat, you have a large range of options. Here are some of them:

CLUTCH These are designed to hold ropes under tension, normally in conjunction with a winch. They offer good holding but are slow to release, often needing to be tensioned on a winch to release the line – meaning they're not as suitable as cleats for lines that need constant adjustment. You'll find that cheaper clutches use more basic cam systems, which work perfectly well but can lead to increased chafe due to the way they release the rope.

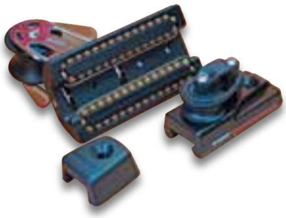
CLEAT There are many variations on the theme of the humble cleat. V-cleats are suitable for light lines only, while clam-cleats will work for bigger lines – but wear easily and are easy to release accidentally. They are ideal for often-adjusted light control lines, such as genoa car adjusters.

HORN CLEATS Old-fashioned mooring-style cleats still have a place on a modern boat – they are useful for mooring lines, flag halyards and lines which don't get adjusted very often. They are a cheap way to make off seldom-adjusted ropes. But for sheets and halyards, more modern clutches and cleats make adjusting lines much easier and safer.

CAM CLEATS Cam-cleats with spring-loaded jaws are probably your best bet for easily-adjustable lines such as kicking straps, spinnaker pole downhauls etc. You can add a 'saddle' on the top to stop the lines going walkabout.

VARIATIONS ON A THEME Some newer products, such as the Spinlock PX cleat, aim to bridge the gap between clutches and cam cleats, offering clutch-style holding while being easy to release. They are not suitable for tensioning with a winch, but have the advantage that they can be operated from afar.

Genoa tracks

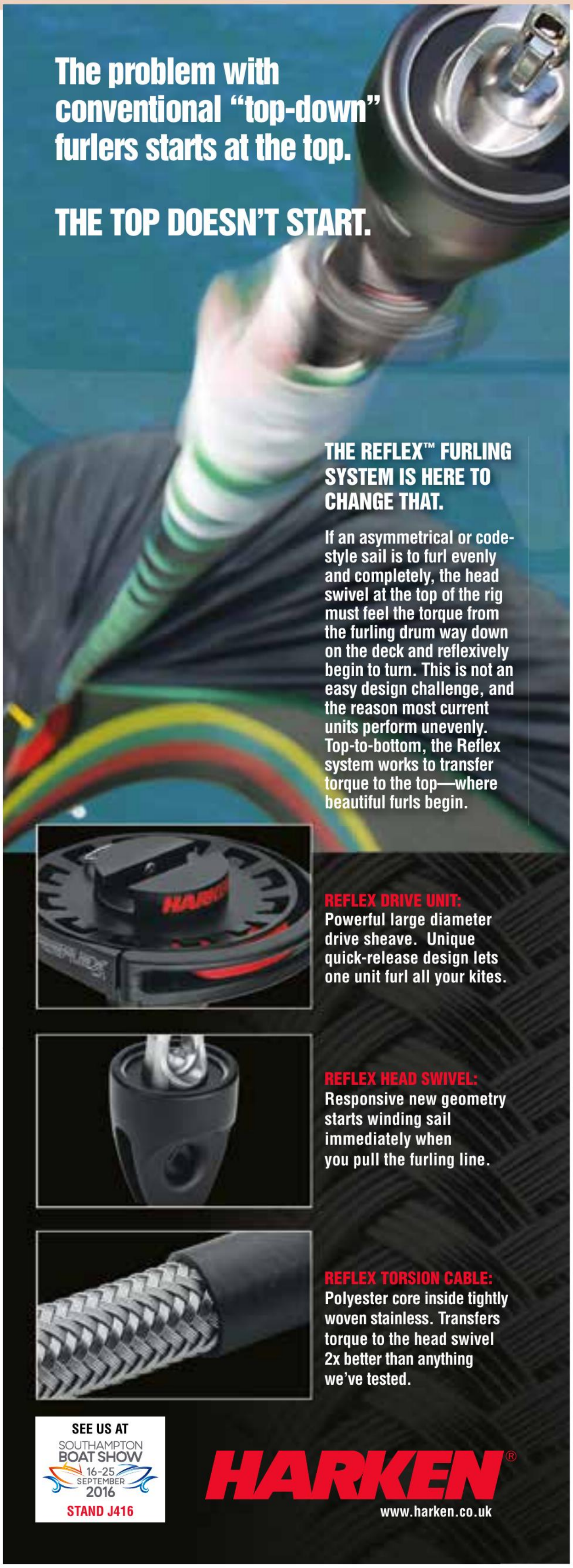


Many boat owners will upgrade their jib sheet tracks and cars as part of a deck gear upgrade. Being able to easily adjust the sheeting angle is possibly the biggest single improvement you can make to sail trim, especially if you have a roller-furling genoa.

What is available?

Pin-stop cars and tracks are the simplest movable sheet leads available. Normally incorporating some sort of T-bar track, they can't be adjusted under load. On the plus side, they're simple, easy to operate once the load has come off, and easy to number to replicate your positions on each tack.

At the other end of the scale are all-singing, all-dancing ball-bearing jib cars. These can be operated under load. They let you constantly adjust the lead, and are particularly good for pulling the car forward after rolling in a bit of jib. They are adjusted via a purchase system and a cleat.



The problem with conventional "top-down" furlers starts at the top.

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Get-you-home sail repairs

Ben Meakins tries out some useful temporary sail repair methods that will tide you over until such a time as you can get to a sailmaker

Regular inspection of your sails will help to avoid any major problems

Most of us spend much more time servicing our engines than we do our sails, which is a shame, given that the sails are the main motive power for most sailing boats. They have a hard life, being flogged, flapped and dragged around obstacles every time they go up. It's surprising that they last as well as they do!

Day and weekend sailors don't experience sail damage so often, with most sails spending most of their lives under sail covers: but talk to anyone who has undertaken a longer passage and you'll find many a tale of tearing sailcloth and days on end spent stitching in a repair to a relatively new sail while running down the trade wind routes to the Caribbean and Pacific cruising grounds.

Modern sailcloth materials are impressive, with better strength and longevity, resistance to tearing and UV damage than traditional sails – but they still tear and chafe. If your sails are damaged during a day-sail, cruise or longer passage, you need to be able to fix them – or make a repair strong enough to get you home and to a sailmaker.

This article will focus on the kit and some basic techniques that will allow you to get home with all canvas flying – but it's a good idea to get the sail to a sailmaker as soon as you get home for a proper repair to be carried out.

Some long-distance cruisers, like this crew, have the facility to use a sewing machine, but most of us must rely on hand-sewing repairs

Mahina Expeditions/ www.mahina.com

Essential bare-minimum sail repair kit...

Palm
To push needles through sailcloth without damaging your hands

Needles
A selection of sailmaker's needles in various sizes

Twine
To stitch up any sails – and also useful for whipping lines

Sticky-backed Dacron
To patch tears and holes

...and a fully-featured sail repair kit

Needles A selection of sailmaker's needles in various sizes

Palm A well-fitting, good-quality palm will make things much easier

Awl For making holes, an awl – along with a chopping board – is ideal

Quick-unpick For quick and easy undoing of old stitching – and undoing any mistakes!

Sticky-backed Dacron As much of this stuff as you can carry will make repairs more effective

Spinnaker repair tape Ideally in all the colours of the spinnakers you have on board

Double-sided tape A good-quality double-sided tape will help to repair seams and other areas by holding two bits of cloth together while you sew it

Leech tape (folded) A length of leech tape will let you cover frayed or damaged edges of sails for repair and cover the sticky Dacron

Pliers To pull needles through sailcloth when a palm won't do the job

Candle stub to wax needles Either candle wax or silicone spray will help get the needle through, especially if you're using double-sided tape to hold the seam together

Wet/dry paper Useful for polishing and de-rusting needles

Waxed twine Some sort of waxed twine will make your repairs much easier – it glides through holes

Duct tape A useful standby when nothing else is available

Good scissors The best-quality scissors you can fit in will make life much easier

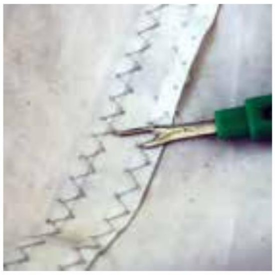
Acetone Although difficult to store, acetone does the job like nothing else when you're trying to decontaminate an area of a sail prior to sticking

Length of webbing Webbing is useful for repairing leeches and chafed areas

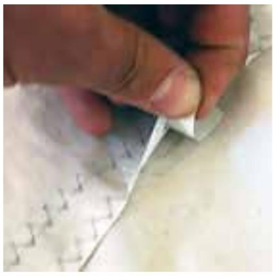
Dacron sail repairs

Mending seams

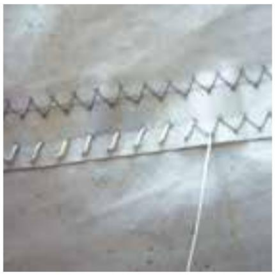
Seams are liable to come apart when the stitching has become degraded by UV light and breaks up. This often happens where the seam has also been rubbing against a shroud or line. It's easiest to repair before it breaks, so a regular inspection for loose and rotten threads is worth your while, but if you don't catch it in time…



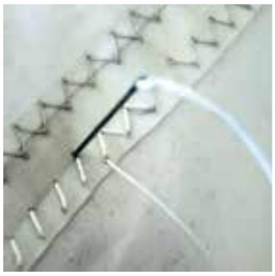
1 First, remove all damaged stitching on both sides of the sail using a knife, scissors or, ideally, a quick-unpick thread cutter.



2 With the rotten or damaged section removed, it's helpful to stick the seam back together. Double-sided tape is ideal to avoid the seam shifting.

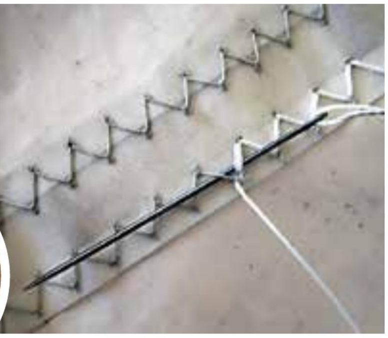


3 With the seam stuck together, you can stitch it. In heavy cloth and to help pass through the double-sided tape it can help to make holes with an awl. Stitch one half of the zigzag first…



4 …and then go back on yourself, stitching the other half of the zigzag. Use the same holes where possible and try to keep your stitches and the tension in the twine even.

5 Finish by tying the line off with a knot. Melting it a little with a lighter can help everything stay attached.

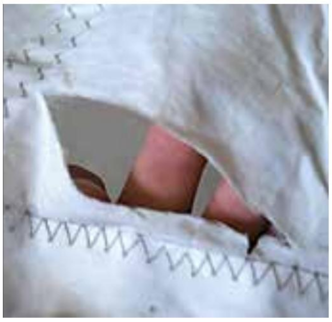


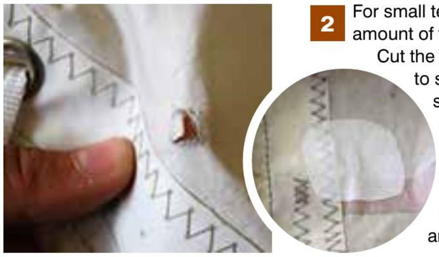
Dacron sail repairs continued

Holes and tears

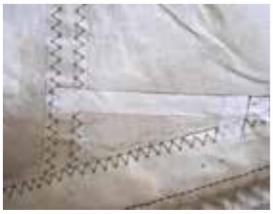
Tears in the fabric of the sail, as opposed to failed seams, are harder to repair. Here, sail repair cloth is essential. Unfortunately, you'll need the sail to be dry for it to stick.

1 Rinse the sail with fresh water to remove salt, and dry it in the sun or in front of a heater if possible.

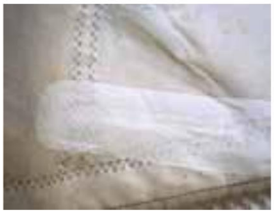




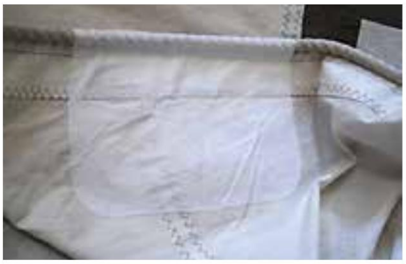
2 For small tears, a small amount of fabric will suffice. Cut the sail repair cloth to size, one for each side, and round off the corners to avoid it lifting. Stick it down well, pressing out all bubbles and creases.



3 For bigger repairs, consider using a few layers, with the first layer narrow and used to 'stitch' the sail together...



4 ...and the later layers increasing in size to reinforce the repair and ensure the edges of the tear stay aligned.



5 This repair is finished off with a large sheet of sticky-backed Dacron, stuck on both sides and around the luff of the sail to keep everything together and spread the load.

6 If the cloth isn't sticking properly it may help to sew around the edge of the repair to secure it. To avoid weakening the remaining material, this is only worth doing on big repairs where you won't find a sailmaker for some time.

Leech repairs

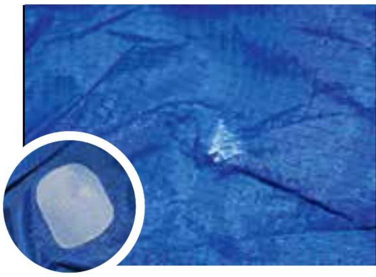
Webbing can be useful here, in order to sew a strong edge onto a damaged leech or to add extra strength to a batten pocket repair. Alternatively, a length of folded leech tape will help to finish off any edge repairs.

Sliders

Here again, Dacron cloth is your friend. If an eyelet has pulled out, you're best off removing it completely and putting a layer of cloth on each side. If you can't avoid using the sail, the plastic 'snap-on'-type eyelets are useful as a temporary low-load repair. It's also worth keeping spare plastic shackles and sail slides in your repair kit for easy replacement and repairs.

Spinnakers

With the lightweight nylons used for spinnakers, it's best to avoid sewing through the sail if at all possible as this may affect the spinnaker's shape. For small tears it's best to use a single layer of repair tape, but bigger repairs require a layer on each side of the sail. If the repairs are too big, however, it may be best to not use the sail until it can be properly repaired by a sailmaker.



Modern laminate sails

Laminate sails are similar to repair to Dacron – except that they generally don't respond well to stitching, especially when they reach a certain age. That means you'll need some serious tapes – and the sail will need to be dry for them to stick. Recently, new products have been introduced which offer some serious adhesive power. One of these is Dr Sails, a two-component epoxy base adhesive designed for use on sailcloth, which cures in 30 minutes. It's worth patching laminate sails as soon as you start to notice any degradation or tears in the weave to avoid the laminate breaking down.

RENAULT
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Eight tips for effective repairs

1: Keep it flat

When stretching out a sail for repair, use a table or pontoon: but if you're on board a small boat and struggling for space, a floorboard or washboard will give you a portable flat surface.

2: Patch both sides

For tears, patching both sides is the only way to avoid snags, and it gives the repair a much better chance of staying in place. Here you can see a nick in the sailcloth is secured by a repair on one side, with another to go.

3: Avoid puckering the sail

When repairing spinnakers, make sure the edges of the repair line up and you're not inducing any creases into the sail – it'll add stress and lead to an early failure of the repair.

4: Remove rust from needles

Rust can add a surprising amount of resistance to a needle as it passes through a sail – use wet/dry sandpaper to polish a needle if you don't have a shiny new one.

5: Round the edges of patches

Don't forget to round off the edges of any patches to avoid them snagging and taking the whole repair with them.

6: Heavy-duty repairs

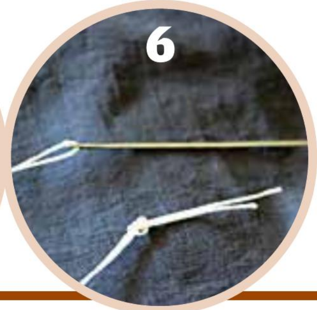
For repairs in heavy cloth or that require lots of strength, double up the twine. This effectively doubles the strength of the repair for little extra work.

7: Check the rest

If a seam comes apart, check the remainder with an awl or a screwdriver to ensure that the rest won't come loose.

8: Keep it moving!

Use silicone spray or beeswax to keep the needle lubricated: it will help to keep the adhesive from the double-sided tape off the needle.



8
SILICONE SPRAY

Preventative maintenance

There are some things you can do to keep your sails in a condition where they won't tear.

Remove them when not using them

Take your headsail off the furler and put the sail covers on as soon as you get in to avoid unnecessary UV damage.

Chafe patches

Adding chafe patches to high-wear areas of your sails can pay dividends. Adding webbing reinforcement to headboards that chafe on the backstay, or leather patches to areas where sails chafe on stanchions or shrouds, can prolong their life and reduce the chance of having to make a repair.

Boats heading off on downwind ocean passages often tape pipe lagging to their spreaders to avoid chafe on the mainsail.

Rotten stitching

Regular checks for rotten stitching are a good way to ensure your sail's seams will stay intact.

UV strips – designed to be replaceable

If your UV strip is degrading, don't worry – they can be discarded. Drop the sail off at the sailmaker for a new one to be fitted before it starts to fray or tear.

Leather adds extra chafe protection to high-wear areas, like clews

Check your sails for loose and damaged stitches to avoid issues

UV-strips are designed to be replaced – here, a sailmaker fits a new one

How to service your engine

The unique challenges of the marine environment mean regular engine servicing is essential for any boat owner. Winter is the ideal time to do this, making next spring's launch much less of a daunting task. In this guide we show you the six main areas which need annual checks or attention

1 **Fuel system**

2 **Oil changes**

3 **Cooling system**

4 **Air intake/exhaust**

5 **Batteries**

6 **Alternator belt**

1 FUEL SYSTEM

Filters are essential to keep water and foreign particles out of your engine. Most marine systems have two fuel filters: a primary filter placed in the fuel lines between the tank and engine, and a secondary filter between the fuel lift pump and the injection pump.

Checking and replacing the primary fuel filter

The type of primary filter found on most small boat installations comprises a filter element with a glass or metal bowl underneath to catch water and heavy sediment. These are held together with a long bolt running through the centre of the entire system.

You should check regularly throughout the season for water having collected. It will be clearly visible at the bottom of a glass bowl; metal bowls will require occasional draining to check.

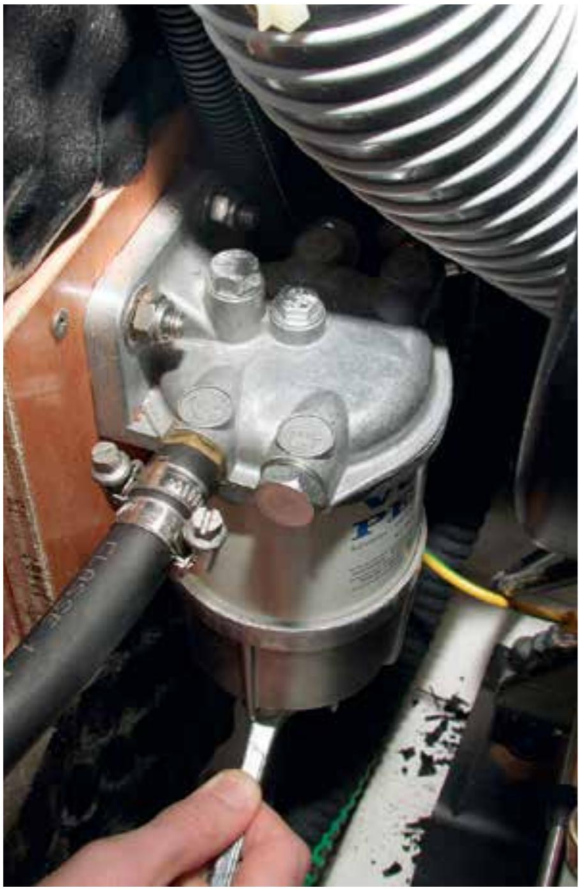
To drain the filter bowl, there will be a cock or plug at the bottom. Hold a container underneath and open the cock or loosen the plug. Once any water has passed through you should be rewarded with a stream of clear fuel and can then close the cock or screw the plug shut.

Replacing the filter is usually recommended at intervals of around 200 hours, although you should check the engine manual. First, remember to close the fuel stopcock to stop fuel draining from the tank. Some systems have stopcocks on both sides of the filter, which minimises loss from the fuel pipes and hence the amount of air a new filter introduces to the system.

Diesel is messy stuff which will get everywhere if not contained, so before touching the filter make sure you have measures in place to catch the fuel which will drain from the filter. A bowl below allows easy access when working, or if there isn't space try hanging a plastic bag around the filter. Unscrew the central bolt, allowing the filter and bowl to separate from the bracket and the fuel to drain into the bowl or bag.

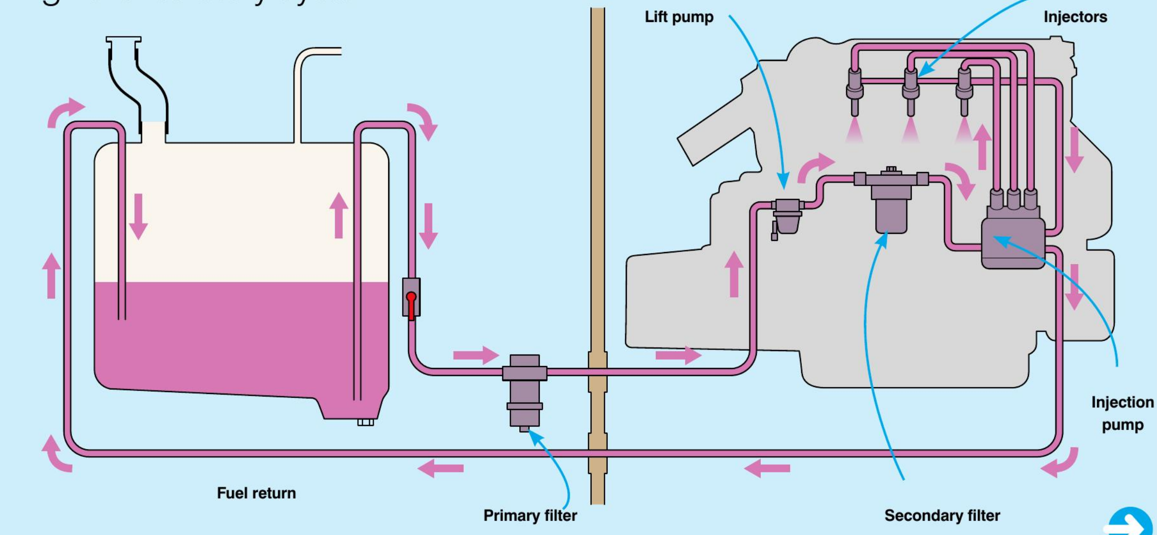
If the canister has not come away it may need a slight tug to separate it from the bracket. Check the sealing rings between the bracket, canister and bowl – they don't need replacing every time, but as new filters usually come supplied with seals you may prefer to do so.

To fit the new filter, simply reverse the process. It's best to assemble the base plate, bowl and filter as a single stack before offering it up and inserting the bolt. Finally, tighten the bolt firmly with a spanner.



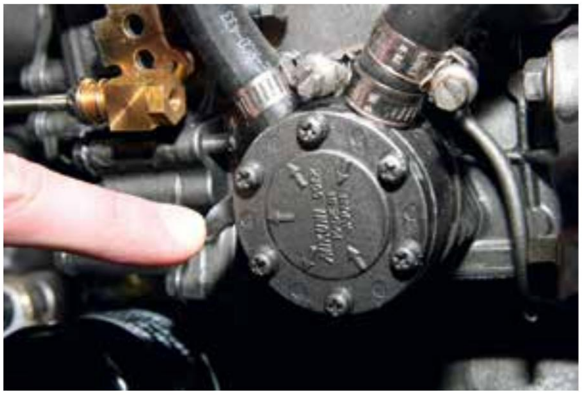
PRIMARY FILTER **Drain the filter by loosening the plug at the bottom**

Engine circulatory system



INJECTION PUMP BLEED You may need to prime the injection pump

INJECTOR BLEED Take care when bleeding the high-pressure system



LIFT PUMP LEVER The lift pump pressurises the low pressure system

Replacing the secondary fuel filter

The secondary filter is generally one of two types: a spin-on filter similar to car oil filters, or a type similar to the primary filter described in the previous section, without the separator bowl.

To replace a spin-on filter, unscrew the filter with a filter wrench until you can just move it by hand. Place a plastic bag around the filter and continue to unscrew it, allowing the fuel to drain into the bag.

Check the area where the new seals will sit for grime and wipe if necessary. Having first applied a smear of diesel to the sealing ring, screw the new filter in place: hand-tight is sufficient if access is good enough to apply your full force, otherwise use a filter wrench – but only gently!

[Note: Some engines have fuel strainers fitted under the domed top of the lift pump. This should be removed and cleaned in paraffin or diesel.]

SECONDARY FILTER Tighten the filter firmly – hand-tight will be enough

Bleeding the system

Changing the fuel filters allows air into the pipes. For the engine to run properly this must be 'bled' by driving it out under slight pressure from high points in the fuel system. Some engines are self-bleeding and can vent air without assistance, but most require you to carry out a few simple steps.

Firstly, make sure you have plenty of fuel and that all the valves in the fuel lines are fully open. Try to operate the lift pump lever – if it won't move or is reluctant, hand-turn the engine half a revolution to move the drive cam, and try again.

If your primary filter is below the level of the fuel in the tank, and your fuel is drawn directly from the bottom of the tank rather than via a dip pipe, you can fill the primary filter simply by cracking open the bleed screw on the top. You should see the bowl fill with fuel, and once clean, bubble-free fuel starts to flow from around the bleed screw, close it. There may still be air on the downstream side of the filter which will need to be vented using the method described below, but having already filled the primary filter accelerates the bleeding process.

SECONDARY FILTER BLEED Slacken the screw on the filter until bubble-free fuel escapes

In either case, the next stage is the secondary filter. Open the bleed screw and operate the lift pump. This may take several minutes, especially if you have to fill the primary filter this way. Fuel should start appearing around the bleed screw; once this is free of bubbles you can close the screw.

If that's not enough...

For Yanmar GM engines, Perkins, Thornycroft and Kubota-based units you will also need to prime the injection pump. The process is similar to that for the secondary filter – open the injection pump bleed screw and operate the lift pump until clear fuel emerges. Older pumps may have two screws – bleed these in turn, starting with the bottom one.

That completes the low-pressure part of the system and should be sufficient. Try starting the engine – if it runs smoothly, you've finished. If not, switch it off and bleed the high-pressure part of the system. Back off the injection pipe nuts a couple of turns, open the throttle fully in neutral, and crank the engine. Use short bursts to avoid damaging the starter motor.

Once you see spurts of clean fuel coming from around the injection pipes, you can tighten the nuts and start the engine. Keep well away from injection pipe nuts while cranking the engine – the pressure of the fuel is sufficient to pierce your skin.

TOP TIPS

- **A smear of diesel on the sealing rings of fuel filters (oil for oil filters) helps them bed in smoothly when tightened**
- **Filling the primary filter with the lift pump is a tedious task. Even if you have a dip pipe fuel system you can sometimes shortcut the process by opening the filter's bleed screw and blowing down the fuel tank breather pipe to lightly pressurise the tank and drive fuel into the filter**

2 OIL CHANGES

Manufacturers' recommendations for oil change intervals vary, but for most boat engines an annual oil change is adequate. Carrying this out at the end of the season makes sense, as engine and gearbox oils contain additives which help inhibit corrosion. The old engine oil will also have become contaminated with sulphur from diesel combustion, forming sulphuric acid which can accelerate corrosion through the winter months.

Engine oil

Most engines have a sump plug which can be used to drain the oil, but boats being boats, there's rarely room to access the plug, let alone have a tray in place to catch the oil. Some engines have a pump fitted to remove the oil, or you can buy a pump to allow you to extract it from the dipstick hole.

To change the oil, first run the engine up to its normal operating temperature. This thins the oil and stirs up any sludge from the bottom of the sump so that it can be removed with the oil.

Warming the engine normally takes about 15 minutes, so to avoid waiting it's worth planning some time at the end of a day on the water when the engine is already hot. Extract the oil using the drain plug, cock or pump.

OIL REMOVAL Drain the oil or pump it out from the dipstick tube

ENGINE OIL FILLER Add a little less than the suggested quantity of oil

OIL FILTER Loosen it with a filter wrench until you can move it by hand

LESS MESS Wrap a plastic bag around the filter to catch spilt oil

Use a filter wrench to back off the oil filter until it's just hand-tight; then place a plastic bag around it and unscrew it. Give the seal on the new filter a smear of oil and screw it into position. Tighten it as firmly as possible by hand – this is usually enough, or for safety nip it up with a filter wrench.

Check the handbook for the grade and quantity of oil required, but don't be too concerned if the engine takes a little less – you rarely manage to extract all the old oil. To fill, remove the oil filler cap, wiping away any dirt from around the rim, and wrap a rag around it to confine spillage. Pour in the oil, stopping just before the recommended amount to check the level with the dipstick. You may need to top up the level a few times as the oil works its way down into the crankcase.

Gearbox oil

Opinions vary on how often you should change the gearbox oil, and it's certainly less critical than the engine oil as there are no contaminants from combustion. However, it's still worth changing regularly to renew the corrosion inhibitors and remove any particles that could damage the gears.

Firstly, check the colour of the old oil. It should look clean: if it's black you may have an overheating problem, if it's a milky colour, water may be getting into it. In either case, you need to fix the problem before changing the oil.

Assuming all is well, remove the dipstick and use a pump to extract the oil. Replace with the oil recommended in the manual, usually either a standard engine oil or automatic transmission fluid, and check the level with the dipstick. Gearbox dipsticks often screw in place – if yours is of this type, don't screw it in to take the reading as the stick measures from the bottom of the thread.

Used oil, filters and oily rags all need safe disposal, so find your nearest facility before you start work. Some marinas and boatyards have a disposal service, or you can find your nearest municipal site at www.oilbankline.org.uk

GEARBOX DIPSTICK Check gearbox oil from the screw-thread bottom

3 COOLING SYSTEM

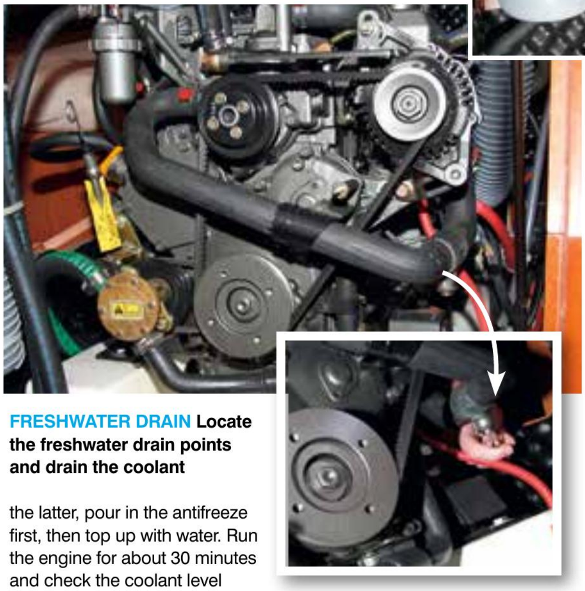
Even small diesel engines now usually have indirect cooling, so changing the coolant is a job most boat owners will need to undertake. Like the oil, it's a good idea to do this at the beginning of winter. Apart from its obvious purpose of stopping the system from freezing, antifreeze also contains corrosion inhibitors which will help your system survive the winter months.

COOLANT LEVEL Check the level on the header bottle

Freshwater system

Only change the coolant when the engine is cold – when the engine has been running up to temperature and is hot the filler cap is under pressure and can allow scalding steam and water to escape if released.

First remove the filler cap. Locate the drain cocks – there is often more than one – and drain the coolant into a bowl. Don't drain it directly into the bilge – most antifreeze contains highly toxic ethylene glycol.



FRESHWATER DRAIN Locate the freshwater drain points and drain the coolant

Once the system has drained, close the cocks and replace the coolant. The antifreeze/water mix varies on the lowest temperature you want it to protect against, but will be explained on the antifreeze can. You can either pre-mix the coolant in a bottle, or allow it to mix in the engine – if you choose the latter, pour in the antifreeze first, then top up with water. Run the engine for about 30 minutes and check the coolant level again, topping up as necessary.

COOLANT TOP-UP Always top up when the engine is cold – otherwise the filler cap can be hot and under high pressure

Raw water system

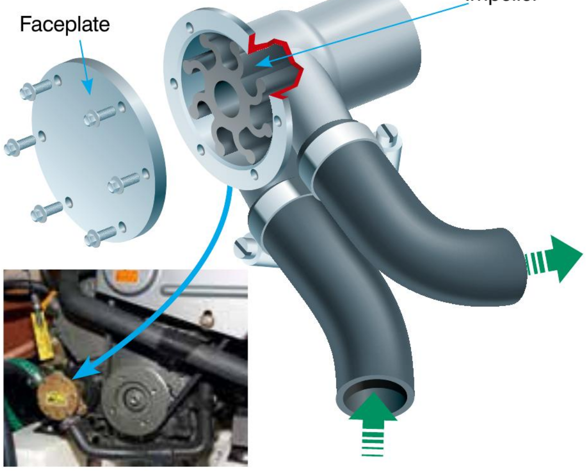
This should be flushed through with fresh water at the end of the season to avoid corrosion. Some boat owners plug the ends of the circuit and fill it with antifreeze for the winter.

Check the inlet strainer and clean if necessary. You should also check the impeller. First remove the faceplate from the pump, then remove the impeller with a pair of needle-nosed pliers, taking note of the vanes' direction. Examine it carefully for cracks – a favourite place for deterioration is at the roots of the flexible vanes. If a vane is missing you need to find it, as the old vane could be sucked through your new impeller and destroy it.

Clean off all traces of the old paper gasket from the faceplate and housing. Smear the new impeller with washing-up liquid for lubrication and slide it back onto the shaft, making sure the vanes are aligned the same way as they were for the old impeller, and that the pin engages with the slot. Replace the faceplate, using a new gasket, and tighten the screws evenly.

RAW WATER FILTER Keep the raw water filter clean

Sea water pump



Other checks

- All engines have a thermostat which regulates the flow of water around the cylinder head and hence its temperature. Unfortunately these can fail and cause the engine to overheat dangerously. Run the engine and check that the water on the output side of the thermostat is warm.

- Many engines have sacrificial anodes fitted to guard against electrolytic corrosion. These need to be removed annually and checked for depletion.

- If the engine in your boat is mounted low enough that the point where the cooling water enters the exhaust is below the waterline, there will be an anti-syphon valve to stop water flowing back into the cylinders and wrecking the engine. These valves can become contaminated with salt crystals, so check them and regularly clean them with fresh water.

4 AIR INTAKE AND EXHAUST

Air intake

Air filters require regular replacement to ensure the free flow of air into the engine and optimum performance. There are three main types:

1. Paper elements are disposable, so if it looks clogged simply throw it away and fit a new one.

2. Some filters use a synthetic wadding. Wash this through with some detergent and allow it to dry before refitting.

3. Older engines may have an oil bath, where a coarse metal screen is coated with oil from a bath below. These need cleaning with diesel or paraffin, and the oil will need replacing.

AIR FILTER Synthetic air filters such as this should be rinsed with detergent and dried before refitting

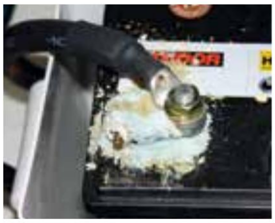
EXHAUST HOSE Disconnect the hose and check for corrosion

Exhaust

Disconnect the exhaust hose from the engine and clean away any deposits, checking for corrosion – spraying with inhibitor can help guard against future problems. If you are winterising your engine, leave the pipe off for ventilation and seal the engine with a plastic bag – if not, refit the pipe.

5 BATTERIES

Even maintenance-free batteries sometimes need maintaining. If you can remove the covers over the cells, check the electrolyte level and top up with de-ionised water if necessary. If you're winterising the boat, try to keep them trickle-charged through the winter months.



CORROSION Clean corroded terminals with baking soda and hot water, then rinse

BATTERY TOP-UP Top up any depleted battery cells with de-ionised water

6 ALTERNATOR DRIVE BELT

Although not a candidate for annual replacement, it pays to keep an eye on your alternator belt for wear or cracking.

When servicing the engine, have a good look and take the opportunity to check the tension. V-type belts are correctly tensioned when you can deflect them about 12mm with your fingers; for flat belts it should be just possible to twist them through 90°.

If your engine has a timing belt check the manufacturer's recommended replacement interval. It's also worthwhile giving it a visual inspection for wear.

ALTERNATOR BELT A correctly-tensioned belt can be deflected with your finger by about 12mm

Repacking a stern gland

Ben Meakins shows how to replace the packing rings on a traditional stuffing box

The traditional stuffing-box type stern gland is in use on many thousands of boats around the world, despite the advent of newer, dripless, water-lubricated stern glands like the Deep Sea Seal.

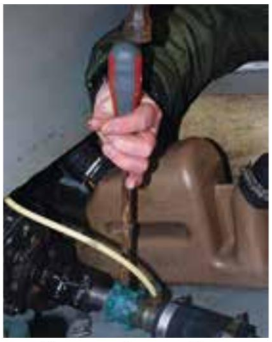
The stuffing box's advantages are many – it's cheap, simple and it works. You simply tighten it up as it wears, greasing regularly.

You shouldn't need to repack a stuffing box very often but, once every few years when it's worn to the point that you can't tighten it any more, or it's leaking more than you'd like, it's time to take it apart.

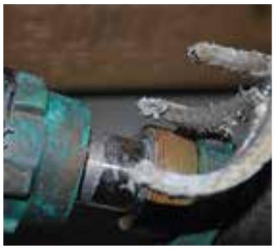
This is a job ideally done out of the water. Some people, however, have repacked them while still afloat by pushing plasticine into the gap around the shaft from under the water before repacking from inside – but it's a risky business, and you'd have to be very confident the plasticine would hold.

Same principle

For simplicity, this guide is illustrated using a gland on a boat with a P-bracket, and a castellated locknut and cap. Types vary – some have a nut and a separate 'pusher', which compresses the packing and will need to be slid out first. Others have a compression plate, but in all cases the principle is the same.



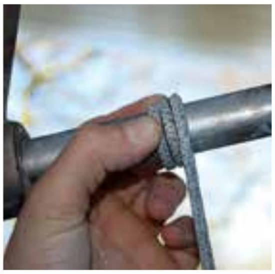
1 **Unscrew the cap. Here we're using a hammer and screwdriver to give the nut a sharp tap to loosen it before unscrewing by hand.**



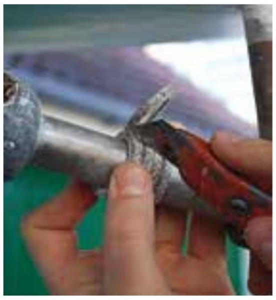
2 **Remove the old packing. You can buy a special tool for the job, but a coarse woodscrew does the job just as well (modern 'turbo' screws with a cutting thread on the tip are even better). A pair of mole grips is perfect for pulling the screw and its packing out.**

3 **While you've got your head in the bilge, check the flexible rubber stern gland hose for delamination or any decay, and replace if at all damaged – it's all that's keeping you from sinking, after all.**

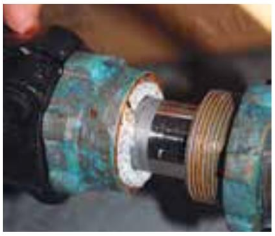
4 **Make sure you buy the same size packing as you took out – it's usually sold by chandleries in pre-packs in 5mm, 6mm, 8mm and 10mm widths. Here we're using 5mm packing.**



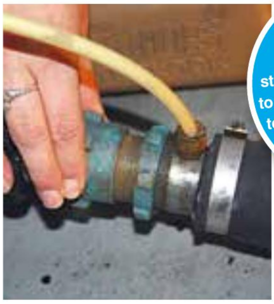
5 **It's tempting to simply wrap a length of packing repeatedly around the shaft, but this can tighten up and get hot. Instead, you need to cut a number of individual rings that are the perfect length to sit snugly around the shaft.**



6 **Wrap the packing around the shaft a few times and hold it tight. With a very sharp knife, carefully slice across all the wraps at an angle of around 45°. This gives you individual rings – three in this example.**



7 **You can now repack the gland. Put the new packing into the cap, making sure the angled joints meet. As you insert each new ring into the cap, stagger the joints so that they don't line up. This will help to avoid leaks.**



8 **You can now screw the cap in and tighten it against the locknut. Ensure the greaser reservoir is full and providing grease to the new packing.**

TOP TIP

Keep some spare stuffing rings, ready-cut to size, in case you need to add more packing in an emergency.

When you're back in the water, you'll need to adjust the gland. Ideally, you're looking for one to two drips per minute while the shaft is turning. Tighten the nut by hand before putting the engine in gear to check for the level of drips, and readjusting (with the engine in neutral) as necessary. After running for a while, check the gland doesn't get too hot. If it does, that's an indication that it's too tight.

How to... BE YOUR OWN DIESEL DOCTOR

Armed with expert assistance from this guide, some basic engine knowledge and a few tools and spares, you can fix the majority of diesel breakdowns or make get-you-home repairs in only a few minutes, says Rupert Holmes

Have you ever wondered how some people manage to get years, or even decades, of reliable service from apparently tired old engines, when others have a string of breakdowns with new models? A big part of looking after an engine is noticing small changes that are hints of impending problems, and then putting things right before they get a chance to develop into something serious.

When making a diagnosis it's all too easy to jump to conclusions and miss what should be an obvious problem. It's vital to keep an open mind and work through a methodical process, no matter how urgent the situation appears to be. Irrespective of the problem, the first stage is to spend a minute taking a careful look over the engine, looking for obvious faults such as loose or broken drive belts and fluid leaks.

An engine failure is often the result of several overlapping issues, so although it may be possible to get it running again and get you home by solving only one of them, it's important to then fix all underlying problems to maintain long-term reliability.

You don't need to be a diesel mechanic to fix your engine at sea – but you will need to know what you're looking for, have a basic toolkit and carry essential spares for likely problems

Know your engine

Make a point of knowing where to find the following items: Fuel filters and water separator • Bleed screw(s) on engine-mounted fuel filter and injector pump • Fuel (priming) lift pump • Raw water pump impeller • Drive belts for alternator and water pump(s) • Cooling water intake skin fitting and filter • Engine start and domestic batteries • Heat exchanger and header tank (if engine is indirectly cooled) • Turbocharger (if fitted) • Compression levers (if fitted).

Tool kit

Open-ended and ring spanners to suit • Socket set • Screwdrivers (a selection of both flat and cross-head) • Pliers • Mole grips • Small hacksaw • Knife • Wire cutter/crimper • Large adjustable wrench • Digital multimeter

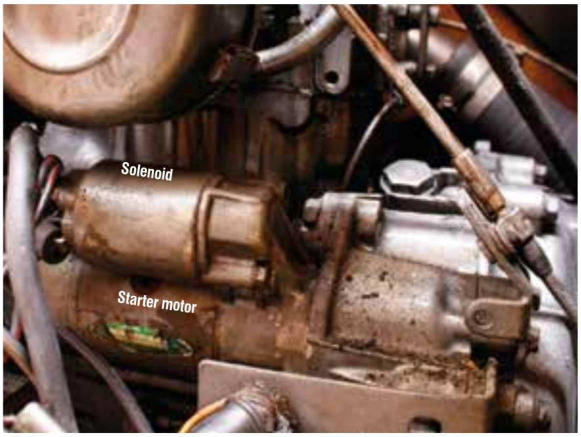
Essential spares

Engine oil • Gearbox oil • Antifreeze • Duct tape • Drive belts for alternator and water pumps • Primary and secondary fuel filters • Water pump impeller • Hose clips • Cable ties • Electrical wire • Electrical tape

Why won't my engine start?

The motor failing to start fairly promptly at the turn of the key is the single most common form of engine failure. In the security of a marina berth this may be nothing more than an inconvenience, but out at sea it can be a different matter.

Even if the battery is in good condition, don't be tempted to operate the starter motor for longer than 10-15 seconds at a time. As well as rapidly draining the battery – and spare capacity will be needed to turn the engine for some of the following tests – spinning the engine on the starter for prolonged periods risks damage to the starter motor and may cause exhaust water to flow back into the engine, with the potential for expensive damage.



A typical starter motor and solenoid set-up. Don't be tempted to operate the starter motor for longer than 10-15 seconds at a time

PROBLEM 1

Starter motor turns engine over quickly, but it fails to start

SOLUTION

■ This suggests the problem is with the fuel system, or due to a lack of a sufficient air supply. An engine's need for large volumes of air is frequently overlooked, so it's worth checking the air filter is not clogged and that the vents to the engine compartment are not obstructed. This only takes a few moments – if all is OK, it's time to start looking at the fuel system (see Problem 2).

■ To get air in, an engine also needs to let exhaust gases out. Internal damage to the exhaust hose can cause a restriction to the airflow. This is often a consequence of overheating, where the heat causes the hose to delaminate internally.

PROBLEM 2

Starter motor fails to turn engine quickly

SOLUTION

■ This points to a fault with the engine start battery, or the wiring between the battery and the starter motor, and you can check this with a cheap electrical multimeter. Start by measuring the voltage at the battery when no load is being drawn from it. A well-charged battery will show 12.6V or more, while 12.2V represents a 50% discharged battery, and at 11.8V the battery is more than 90% discharged. If the voltage is 12.0V or less, the battery is likely to need to be charged up before it will start the engine. This is especially the case in cold weather, when it's not only harder to crank the motor (because of thicker oil) but the temperature also diminishes the battery's ability to deliver power.

■ If the battery passes the no-load test, the next stage is to check the voltage while cranking the engine for 5-10 seconds. Around 9V is the minimum cranking voltage needed to start a diesel engine, although for optimum reliability 10V or more is ideal.

■ A lower figure than this indicates a battery that's unable to deliver enough power to start the engine. Recharging may help, especially if the open circuit voltage was low, but the indications are that the battery is elderly, with significantly less capacity than when new, and should therefore be replaced. If you're at sea with a low battery, however, all is not yet lost...

■ Many older engines have decompression levers, allowing a weak battery to spin a decompressed engine fast enough to start it. Hold the lever(s) in the raised position, while turning the engine on the starter motor for a few seconds. Lower one lever, holding the others up until the engine fires, before dropping the remaining levers in turn.

■ If the battery passes the cranking voltage test but still fails to turn the engine quickly, power is being lost in the wiring somewhere between the battery and the starter motor. Starter motors draw a huge current from the battery so loose, dirty or corroded contacts will limit the current that can reach the starter, with the energy being lost as heat.

■ If any terminals or connections are hot after cranking the engine this is a clear sign of a problem. Connections can become very hot, so don't burn yourself.

■ Dismantle problem contacts, clean them with medium to fine emery paper and reassemble. The engine may start now. If not, it's time to take a closer look at those contacts – the heat test is a quick check that will identify big problems, but a voltage drop test is needed to give a more precise indication of problem connections in the starter circuit.

■ Using a low voltage (eg 0-2V) scale, place the negative probe of the meter on the battery negative post, the positive probe on the terminal clamp, and crank the engine with the starter for a few

Cranking test: battery voltage too low for starting at 5.91V

seconds. Repeat this process for each connection between the battery and starter motor. The meter reading across each contact should be less than 0.2V, and the total reading for all contacts between the battery post and the starter motor less than 0.6V. If these criteria are not met, dismantle all contacts that fail the test, clean them with emery paper, reassemble and try starting the engine again.

Place one probe on the battery terminal and the other on the terminal clamp

PROBLEM 3

The starter motor fails to engage

SOLUTION

■ Sometimes a jammed starter motor can be persuaded back to life with a sharp tap from a mallet. It may also help to remove the starter to clean and re-grease the pinion that engages the flywheel.

■ Starter solenoids sometimes fail, but the problem may be caused by insufficient voltage reaching the solenoid. Check the voltage at the solenoid – it should be around 12V. If the voltage is low a simple bypass may get you started, but in the long term consider thicker cable – resistance increases with heat, so cables in hot spaces need higher ratings than those in cool ones.

PROBLEM 4

Engine won't start easily from cold

SOLUTION

■ Most diesel engines have pre-heaters (glow plugs) that warm the air in the intake to improve cold starting. If these malfunction starting performance will be impaired, but it's a simple matter to check whether they are warming up sufficiently. Unscrew the pre-heater, reconnect its wire and switch on the engine's ignition. The glow plug should heat up enough to create steam when a damp cloth is held against it (use thick leather gloves). If it does not heat up, first check the wiring. If this proves OK, then the plug will need to be replaced.

Don't...

...rely on Easy Start spray to help with an unreliable engine – it's a powerful solvent that can wash oil from the cylinder bores, accelerating engine wear. However, as a last resort, where the alternative would put the boat in danger, it may be useful. I keep a can on board for this reason, but it's never been used in the decade I've owned my boat – as can be seen from the condition of the can!

Why won't my engine run properly!

PROBLEM 1

The engine stops running

SOLUTION

■ This can be a heart-rending moment for any skipper, but in the majority of cases it's possible to get the engine running within a few minutes. There are many possible reasons for engine failure, from fuel starvation problems to a rope round the prop, so it's important to approach the diagnosis in a systematic fashion. Overheating and low oil pressure may also cause the engine to stop, but if they're functioning correctly the alarms should sound a warning before this happens.

■ If no alarm sounded, put the gear selector in neutral and turn the engine on the starter motor. If it does not turn this could be an ominous sign, suggesting the possibility of serious damage caused by overheating or low oil pressure. Before jumping to these conclusions, however, do the starter motor checks as described on the opposite page.

A tangled prop could be the cause of a sudden engine failure

■ If the engine does start, keep it in neutral while trying to rev it – will it do so freely? If it stalls or seriously hesitates, this points to an air or fuel problem. A supply of air is just as vital for efficient combustion as clean and plentiful fuel – around 1m^3 of air per minute for every 10hp is a useful rule of thumb.

■ If the engine runs freely, however, try putting it into gear at idling speed. If it stalls this could indicate a fouled propeller or a gearbox problem, although the latter is statistically unlikely. Don't be tempted to immediately leap into the water to free a fouled prop – this can be risky even in apparently favourable conditions.

■ If the engine starts and doesn't stall when put into gear, you're lucky. But don't be complacent – an engine with partially clogged fuel filters or restricted air supply may run at low speed, but not be able to deliver full power. Further use of the engine is likely to exacerbate fuel filter problems, increasing the chances of another breakdown.

PROBLEM 2

Engine turns but won't restart

SOLUTION

■ If the engine turns on the starter motor but doesn't re-start it points to a fuel system problem or lack of air supply as the most likely fault. First check that neither the air filter nor the vents to the engine compartment are obstructed, and confirm that the fuel has not been turned off at the tank or other isolation valve. Many modern diesel engines have a solenoid that cuts off the fuel when the engine is switched off – check the voltage to ensure this is opening when the key is turned.

A dipstick provides an accurate measure of fuel in the tank

■ At this stage you need to be certain you have sufficient fuel – it's all too easy to assume the problem lies elsewhere. Don't just rely on a fuel gauge: checking with a dipstick (above) or sight gauge is much more accurate.

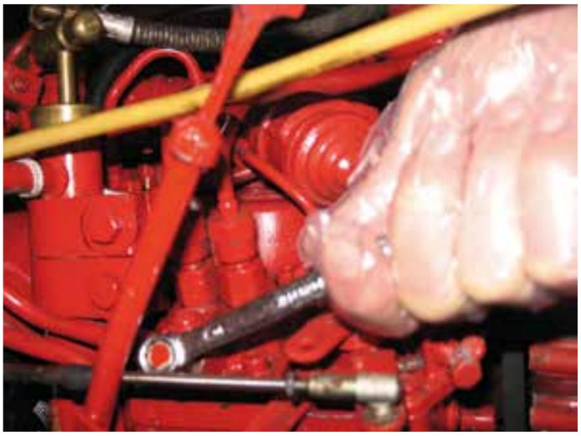
Remove the air filter housing cover to check the filter isn't blocked

- Next, check the water separator bowl under the primary fuel filter located between the diesel tank and the engine. Water here will show as a light-coloured layer below the diesel. It can be drained by loosening the thumbscrew at the bottom of the bowl, allowing it to drip into a container held underneath. If the bowl is full or nearly full of water there's a risk of it reaching the injector pump, causing expensive damage. If that's the case, draining the system and cleaning the tank is a wise precaution if you have the option before restarting the motor.

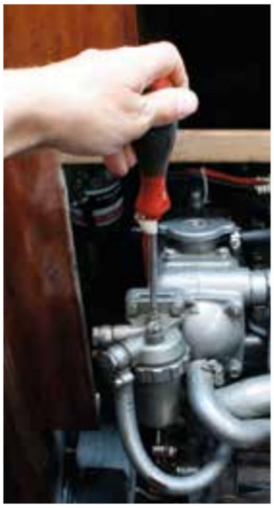
- If you are simply out of fuel, the engine may start right away after adding more, so it's worth a try – although usually air will need to be vented (bled) out of the fuel system (see below). In any case, it may be possible to restart the motor just by bleeding some air out of it, even if full power cannot be achieved – this may buy enough time to get you out of a tight spot.

- Although most modern engines are described as self-bleeding, a degree of intervention is often needed. Loosen the primary bleed screw – this may be on top of an engine-mounted fuel filter or at the injector pump – and pump the manual lever on the fuel lift pump 6-10 times. You're likely to see a mixture of air and fuel bubbles come out from the bleed screw, so keep pumping until there's just diesel and no further air bubbles, then re-tighten the bleed screw.

- If the engine doesn't now start, it may benefit from being bled in the same manner further along the fuel system at the injector pump and in extreme cases by loosening the nuts holding the fuel pipes at the injectors themselves. If the engine starts now don't forget to fully investigate the cause of the air entering the fuel system when you get the chance. Likely causes include air being sucked into the system when low on fuel, partially blocked fuel filters and leaking pipe connections between the fuel tank and lift pump.



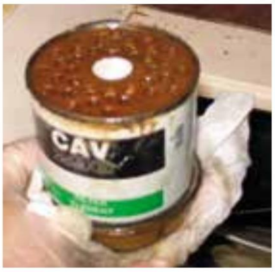
Here's where you might find the bleed screw (or nut) at the injector pump



The primary fuel bleed screw should be easy to find

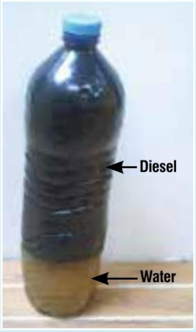
- If it still won't start, this points to blocked fuel filters. These are particularly prone to becoming clogged in heavy weather, as crud that otherwise sits on the bottom of the fuel tank is stirred up in big seas. If this is the case, changing the filters will get you under way once more, but won't solve the original problem: take the first available opportunity to clean the tanks and change the filters again for good measure.

Primary filters are often secured by a long bolt through the fitting



This filter shows signs of being clogged with dirty fuel

Diesel bug



If water is present in the fuel tank, bacteria can establish themselves at the interface between this and the diesel, growing in number until the bacteria or their waste products clog fuel filters. The problem is exacerbated with modern fuels, which have a biodiesel content.

Water in the tank can be minimised by keeping the tank brimmed with fuel, especially over the winter, thus reducing the amount of air space in which condensation can form. Various treatments are available to help prevent or treat diesel bug (see PBO May 2011). However, debris will remain in the tank, with the potential to block filters – so the tank should be drained and cleaned following an infestation to prevent further breakdowns.

PROBLEM 3

Gradual or sudden loss of engine power

SOLUTION

- If power is lost, but the engine continues to operate at a slower speed, the reasons may be similar to those of complete engine failure. An engine that's critically overheating, for instance, will lose significant power. Even if the overheat alarm hasn't sounded, it's worth checking whether there's water coming out of the exhaust, and for other signs such as steam, leaking coolant hoses in the engine compartment, or broken, slipping or damaged drive belts.

- A loss of power is often a precursor to complete engine failure, so problems should be dealt with quickly.

- Sudden loss of performance can be the result of the prop becoming fouled by things like fishing nets, rope or plastic sheeting. In severe cases this could actually stop the engine, but in more mild cases the motor may continue to run. In this instance the revs are likely to drop, the prop may provide little forward drive and vibration will probably be experienced. Look over the side of the boat and over the stern – if the prop is fouled, the water around the boat will look very disturbed due to the turbulence coming off the prop.

- Running the engine in reverse will often help free a tangled prop. After a minute in reverse, alternate between forward and reverse gears. Even if this process doesn't entirely free the prop of debris, there's a good chance it will dislodge enough material to enable you to reach harbour or a safe anchorage.

- If a fouled prop can be ruled out, the loss of power is likely to be caused by fuel system problems, particularly partially clogged filters, fuel leaks or air being sucked into the system, so it's worth following the procedures already mentioned as soon as an opportunity presents itself.

- Loss of power and lots of black smoke at the exhaust point towards a failed turbo on a turbocharged engine. The engine may well keep running – but keep it at low revs only.

Catching problems early

One element of good seamanship is to always have a plan for keeping the boat safe in the event of engine failure. This will vary with each situation – even in confined waters sail boats can often hoist a sail, even if only to buy a little time by running downwind. Otherwise, it's prudent to prepare the anchor and/or fenders and warps for use as necessary. As ever, the precise action to take will depend on the specific circumstances of each situation.

Fitting gauges for temperature and oil pressure will give more warning of an impending problem than the standard alarm buzzers and could conceivably save the boat. For instance, if a temperature gauge is creeping inexorably upwards the prudent skipper would check out likely problems before attempting something like entering a narrow and crowded channel such as the entrance to Portsmouth Harbour. But if all you have to rely on is the alarm you may already be fully committed, with three knots of tide behind you, when the buzzer sounds.

SYMPTOM 1

The engine is overheating

SOLUTION

- Overheating can be caused by a wide number of factors. A surprisingly common one is failure to open the cooling water seacock after working on the engine.

- Running an engine at high revs for an extended period will put systems under more strain than they normally encounter, exposing latent weaknesses. In this situation, after allowing it to cool it may be possible to continue at modest speed without the motor overheating again. The cooling system will need to be checked thoroughly and any underlying problems rectified before the boat next puts to sea.

- Another possibility is a blocked seawater intake, caused either by a blocked filter, or an obstruction being sucked over the intake.

- After checking the seacock, examine the intake filter for debris. After clearing a blocked filter start the engine and look for a flow of cooling water from the exhaust – this may take 20 seconds to flow. If you're lucky the water pump impeller won't be damaged, but if the engine was run for more than a minute or two without cooling water the impeller may have suffered damage and should be inspected as soon as possible.

Seawater intakes can become clogged with weed or rubbish like plastic bags

Check the cooling raw water strainer for blockages

- Plastic bags may float off an intake once the engine is shut down, leaving no evidence of the previous problem other than a burned-out impeller.

- If the filter is clear, examine the drive belts on the front of the engine. Are they in good condition and properly tensioned? Belt wear accelerates rapidly if they are too loose and able to whip or slip.

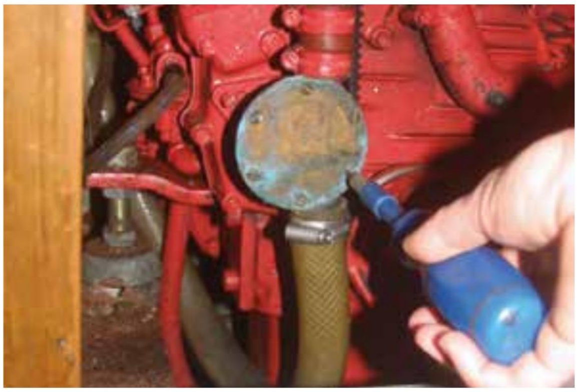
Impeller damage

- The rubber impeller in the seawater pump requires water for lubrication and can be damaged if it runs dry for as little as one minute at high revs. Equally, the vanes of an ageing impeller will adopt a permanent deflection that reduces the pump's efficiency, before eventually breaking apart.

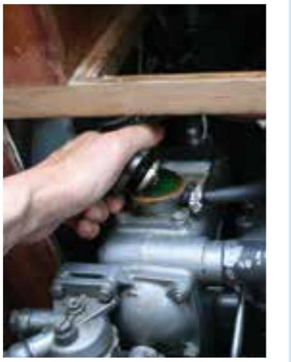
- Remove the faceplate of the pump to inspect it and replace the impeller if damaged, removing any broken elements of the old one before fitting the replacement.

Cooling system types

- Two different types of cooling systems are fitted to marine engines. Directly cooled units have raw water (the sea or fresh water in which the boat floats) pumped around the engine. Indirectly cooled engines are more complex, with a closed cooling system more akin to that of a motor vehicle. In place of the radiator there's a heat exchanger in which water/antifreeze in the sealed system is cooled by the raw water.



Water pump impeller housings are not always as easy to get at as this one



Remove the filler cap to check there is sufficient coolant in the heat exchanger. WARNING: wait for the engine to cool before attempting this

- If all else appears to be OK with an indirect system, wait for everything to cool down before removing the filler cap to check there is sufficient coolant in the heat exchanger. If not, top it up, restart the engine and run it under load for a few minutes. A flow of water from the exhaust indicates the raw water pump is functioning, but indirectly cooled engines have a second pump that circulates coolant around the engine and heat exchanger. The same belt as the alternator often drives this, so this belt should be double-checked and the impeller inspected for problems.

- All marine engines are subject to narrowing of the waterways over time due to a build-up of limescale, which reduces the efficiency of the cooling system. This happens within the engine of directly-cooled engines, or in the heat exchanger of indirectly cooled versions. Neither is a job that can be undertaken at sea, but reducing revs may enable the engine to safely get you home.

- Thermostats rarely cause trouble, but if stuck closed the engine will overheat within minutes of start-up. The thermostat is easy to remove and, as a get-you-home measure, engines can be run without one. In the long term engine wear will increase, and fuel economy will suffer, so fit a replacement thermostat at the first convenient opportunity.

SYMPTOM 2

The oil pressure is low

SOLUTION

■ There are a number of possible reasons for oil pressure problems. Oil pressure rises with engine speed, so if the alarm sounds with the engine running at very low speed or idle, try increasing the revs a little. If the alarm stops within a couple of seconds it should be possible to run the engine at moderate speed without causing damage. But don't risk it if the alarm remains on.

■ The most obvious problem is low oil level, so check this first. If the oil has been replaced at a recent service, confirm the correct grade of oil was used – a common mistake is the use of synthetic modern oils: older engines need a thicker grade. As oil ages it loses viscosity, which reduces pressure, so an overdue oil change may be the problem. This is most apparent when the engine is hot.

Oil pressure problems? First check the oil level and top it up if necessary

■ If the problem is persistent it's also worth checking the wiring of the oil pressure sensor – if the positive wire makes contact with the engine the alarm will activate.

■ Many marine engines are not designed to run for sustained periods at angles of heel greater than 20° – which can be a problem if motor sailing in heavy weather. In this situation, turning the engine off to allow it to cool while reefing the sails to reduce heel may solve the problem.

■ It's always worth checking whether there are other reasons for low oil pressure and rectify them before the boat next puts to sea. These might include a blocked (or partially blocked) oil filter, a worn oil pump and excessive bearing wear. A knocking sound when the engine is under load is indicative of the latter – and it'll only get worse.

SYMPTOM 3

The battery charging warning light activates

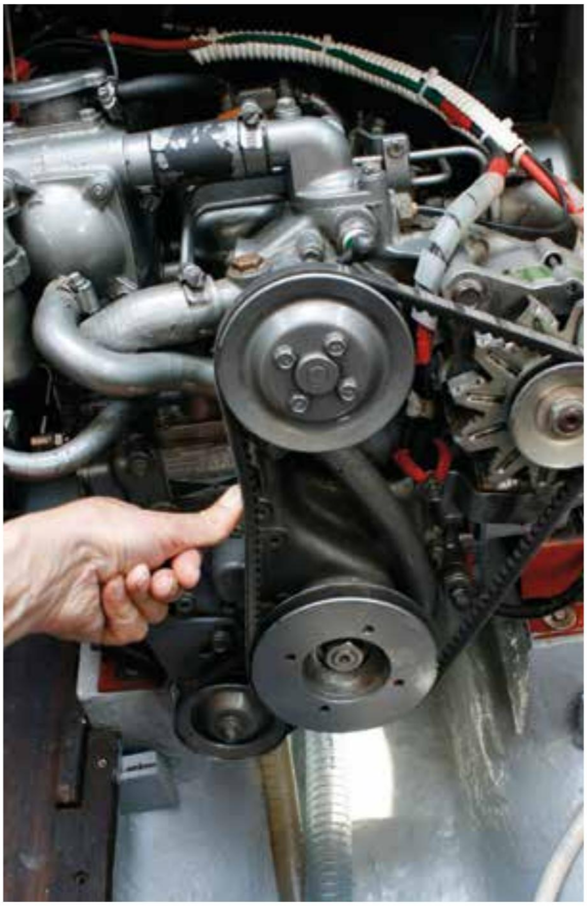
SOLUTION

■ If the engine is not charging batteries, the warning lamp will light, but the alarm buzzer will not sound – in many cases, lack of charging is not a breakdown that must be rectified instantly. If the alternator belt is not also powering a cooling water pump the engine will continue to operate, although batteries will not be charged, so it makes sense to conserve as much electricity as possible.

■ The first check should be of the alternator drive belt to confirm it's not excessively worn, loose or broken. Drive belts are at optimum tension when 10kg of thumb pressure on the longest run between pulleys will deflect the belt by 10mm. A build-up of black dust on the front of the engine is a sure sign of a slipping belt that needs to be tensioned.

■ If the belt is in good order the extent of the problem can be confirmed by checking the voltage of the batteries with the engine running. Ideally it should be above 14V, but this may not be achieved if batteries are relatively large compared to the alternator and are very discharged, or if they are charged through split charging diodes where a voltage drop at the diodes of 0.6-1.2V reduces the 14.4V output of standard alternators.

■ If the voltage at the batteries is less than 13V, then the battery is probably not being charged. If you're under way it's worth monitoring the remaining battery charge by checking the voltage at regular intervals. With no load being drawn a well-charged battery will show 12.6V or more. A figure of 12.2V represents a battery that's 50% discharged, and at 11.8V it is more than 90% discharged.



Ensure drive belts are in good condition and are at the correct tension

The problem with warning lights – especially ones for oil pressure and temperature – is that, unlike gauges, they can't give you any warning of impending trouble

■ After stopping the engine, charging failure can be confirmed by checking the voltage again. If it's the same figure as before, then the engine wasn't charging. It's best to wait at least 15 minutes (ideally much longer) before doing this, to let any voltage changes stabilise.

■ The rectifying diodes built into the alternator unit to convert the AC output into a DC format are particularly susceptible to damage if the batteries are accidentally switched off when the engine is running. If a problem is suspected each of the diodes can be tested with the resistance function of a multimeter – they should have infinite resistance in one direction but pass current in the other. PBO

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How to service your two-stroke outboard motor

Step-by-step guide to servicing your trusty two-stroke

After a long winter indoors, many 2-stroke outboards are reluctant to start. A simple service should make yours more reliable. Here, Steve Dawkins of Bursledon Outboards shows PBO's Ben Meakins how it's done

3.3
MARINER
3.3

Rules within the EU mean you can no longer buy a new, small two-stroke outboard motor in Europe, but their light weight, compact size and longevity means tens of thousands of used examples are still to be found on boats from Caithness to Crete.

The start of the season is when any unreliability issues are most likely to rear their ugly head, and there's a good reason for that. 'Most people assume they can just take their outboard off their boat and put it straight into their shed for the winter,' technician Steve Dawkins told me in his workshop at the Cabin Boatyard on the Hamble River. 'Then, come the spring, they're surprised when it doesn't work.'

I kept quiet. My family's outboard had been sitting forlornly in a garage among a pile of ropes, fenders and sails since it came ashore at the end of last summer.

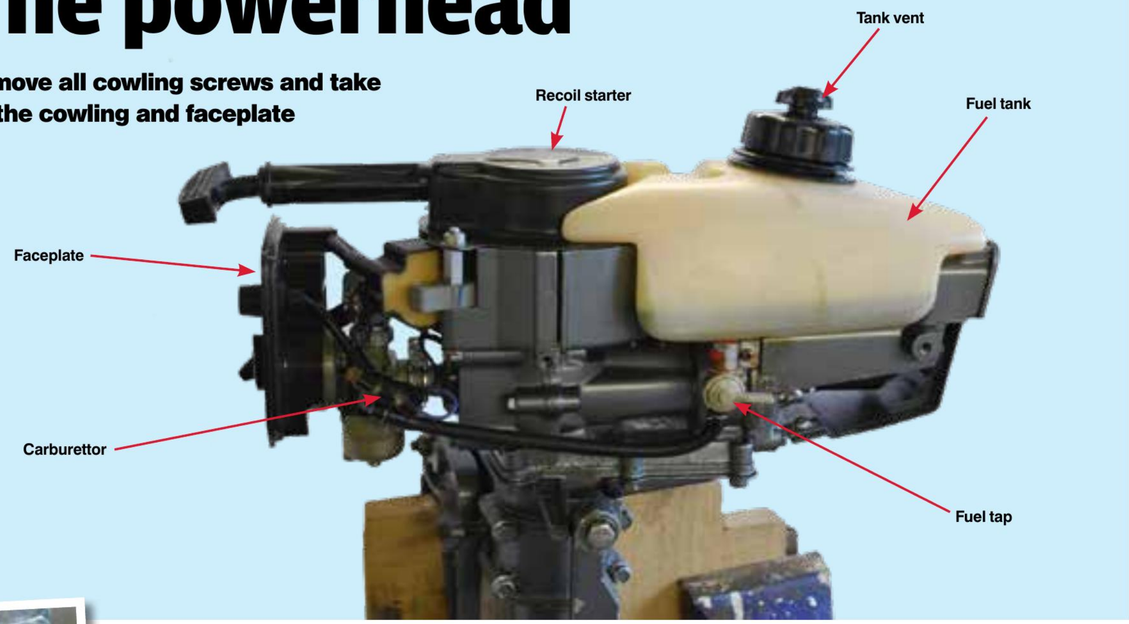
Do it yourself!

This step-by-step guide takes you through the service of a small two-stroke outboard. The pictures show Mariner 3.3hp and Suzuki 2hp outboards, and while other makes of engine are subtly different, the main components should be recognisable. Anyone with a reasonable level of technical ability should be able to breeze through the service, but if you're in any doubt, take yours along to a dealer. If you are going to do it yourself – and this mostly applies to late-model motors – check first that what you're doing won't invalidate any warranties.

Our 2hp Suzuki has been sitting neglected in a garage all winter. Time for a service!

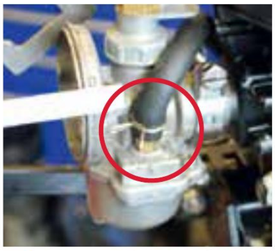
The powerhead

Remove all cowling screws and take off the cowling and faceplate



1. Drain the old fuel

'The most common complaint we get is from people saying it worked fine last year but now it won't start,' said Steve. This is because petrol evaporates over time, leaving behind an oily, paraffin-type residue which gums up the carburettor. So the first step is to drain the old fuel.



1 Remove the fuel pipe from the carburettor by loosening the clip with a pair of long-nosed pliers.

2 Turn on the fuel tap and drain it into a container.

Clean out any residue

3 If necessary, remove the tank and clean out any residue or gunge. There is often a small filter just above the fuel tap.

2. Check the spark plug

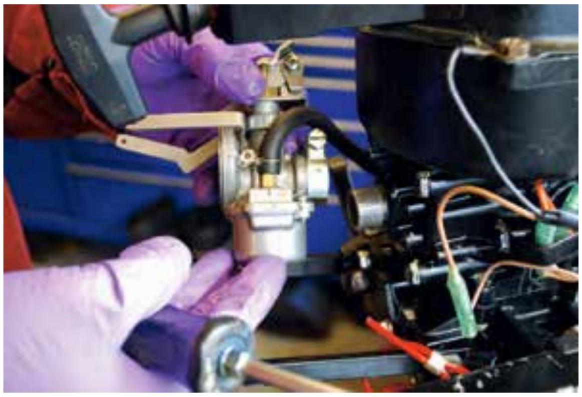
Remove the spark plug with a socket. The electrode of a healthy plug should be a brown or grey colour. If not, clean out any carbon deposits and check the sparking gap matches the recommendation of the engine manufacturer. If the ceramic insulator is damaged or the electrode burnt away, you'll need a new plug.

3. Check the recoil starter

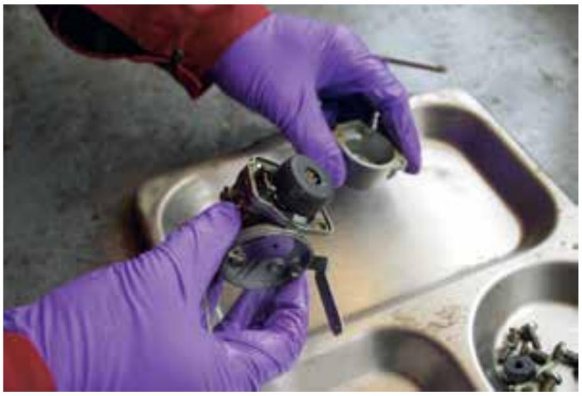
The recoil starter is held on with three bolts. Remove these and turn the starter over. Check for fraying in the cord and give the spring and bearings a squirt of lubricant.

4. Remove, strip and clean the carburettor

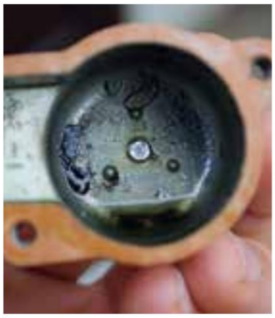
Located on the front of the engine, the carburettor is responsible for ensuring the correct blend of two-stroke fuel mix with air. A clogged-up carburettor means the engine will run rough and won't idle properly. The solution is to remove, strip down and clean the carburettor.



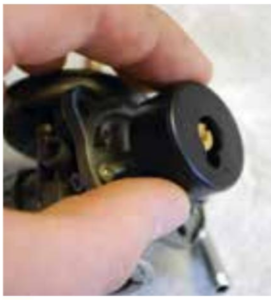
1 Undo the clamp and ease the carburettor off its mounting. Make sure you don't lose the O-ring seal.



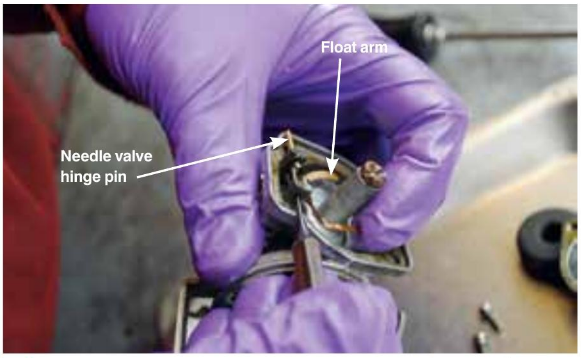
2 Remove the screws holding on the bowl. Do this over a tray so you don't lose any pieces!



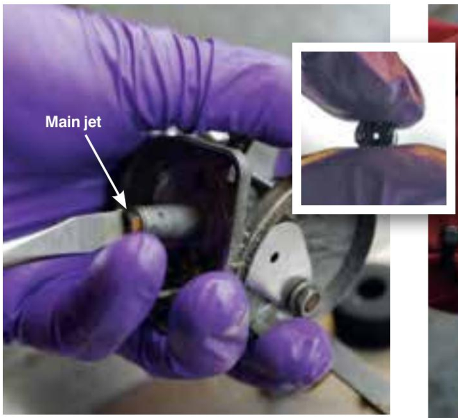
3 Sit the bowl in a container of carburettor cleaner, clean any corrosion or residue with a small wire brush, then leave it to soak for a few hours.



4 Next, remove the float. The float height is important, so at this point it's a good idea to take a photograph of the valve so you can put it back together exactly as you found it.

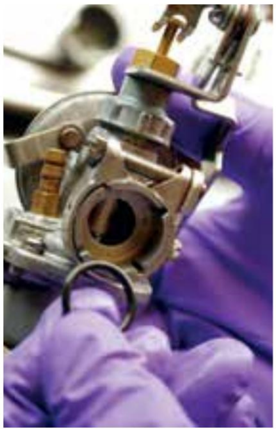


5 Push out the needle valve hinge pin and remove the float arm. On some engines, the needle valve will be linked to the float – so you may have to remove the pin before the float.



6 Next, remove the main jet. Unscrew it, check the hole is clear (inset), and soak it in carburettor cleaner to make sure. 'Nine out of 10 problems we see are down to the main jet being blocked,' says Steve.

7 Now reassemble the carburettor, taking care to put all the pieces back in the right places.

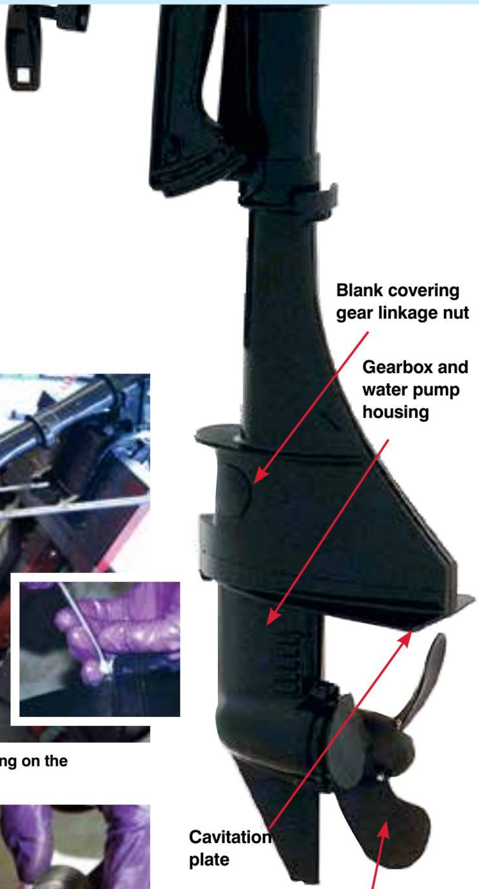


8 Reattach it to the engine. Make sure the O-ring is correctly installed, or you'll have major problems later.

The lower leg

1. Remove the gearbox to check the water pump

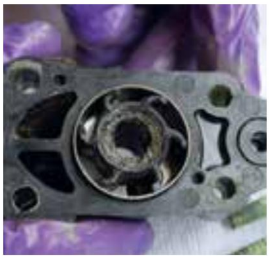
On engines with more than one gear, the pump is located on top of the gearbox unit, so if your engine has gears you'll first need to undo the gear linkage. On smaller engines the pump impeller can be found behind the propeller (see panel, below right).


Blank covering gear linkage nut
Gearbox and water pump housing
Cavitation plate
Propeller

1 Remove the round blank, usually found just above the gearbox. Move the gear lever so you can see the linkage nut and undo it with a spanner.

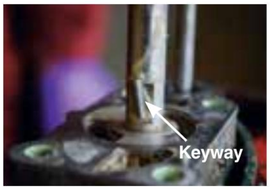
2 Now remove the gearbox by undoing the bolts holding on the gearbox and carefully sliding it out of the lower leg.

3 Remove the pump housing by undoing bolts and sliding it up the propshaft. Make sure you don't lose the keyway (see 6).



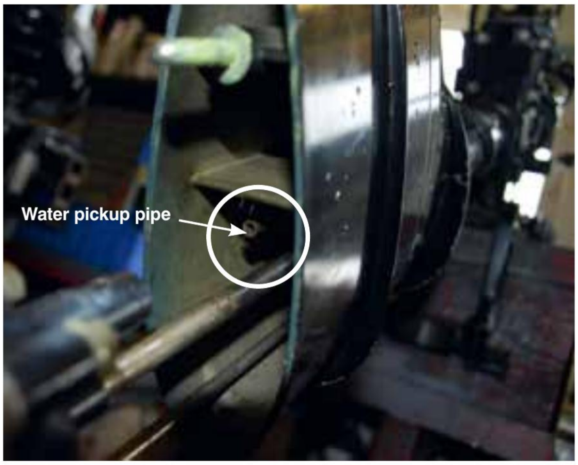
4 Inspect the impeller, making a note of the way it rotates. If it's creased or hard, replace it.

5 Remove, clean and then grease the impeller housing insert.



6 Grease the shaft and stick the keyway in position using grease.

7 Reattach the pump housing and impeller. As you slide it down the last bit, turn the shaft to bed the impeller in correctly.



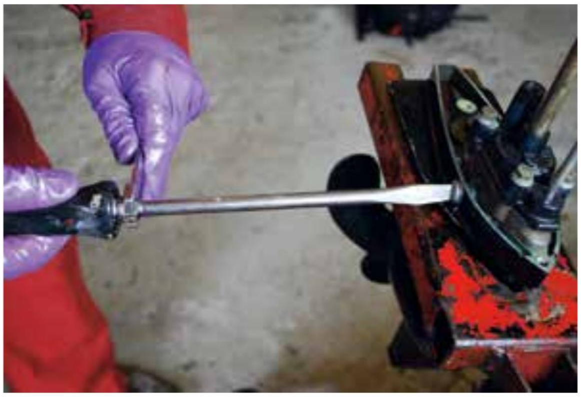
8 Now reattach the gearbox to the lower leg. Carefully slide in the gearbox, making sure the water pickup pipe is unblocked and lined up correctly inside its socket.

On smaller engines with only one gear...

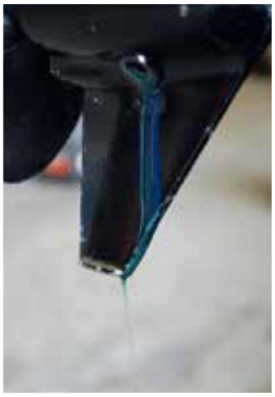
Remove the propeller and then the plate behind it. The water pump impeller can be found behind this plate.

2. Check and replace the gearbox oil

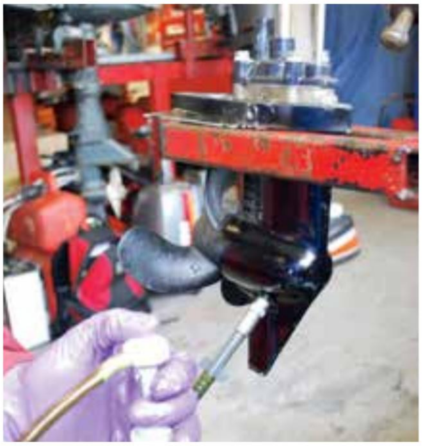
The professionals perform a pressure test to check the seals are still doing their job. Without the right equipment you'll struggle to do this, so you'll have to make do with a visual inspection. One way to see if you have a major problem is to leave the engine standing on a piece of clean cardboard overnight and check for telltale leaks in the morning.



1 Remove both the top and bottom bungs and let the oil drain out into a container.



2 Check the oil for water ingress. If the oil is blue or clear, it should be fine, but if it's cloudy or settled you may have a problem. You can use an oil testing kit to make sure. If there is a leak, take it to a dealer for new seals.



3 Refill the gearbox with new oil from the bottom up – most gear oil comes in a squeezy tube or a pump-action oilcan. It's full when oil starts to come out of the top hole.

4 Replace the fibre washers on both bungs and put them back in, starting with the lower one.

Prevention is better than cure!

Here are Steve's top tips to keep your engine running smoothly.

1 Salt water is an engine's worst enemy – so the engine should be flushed through with fresh water after every use, or it will start to corrode from the inside out.

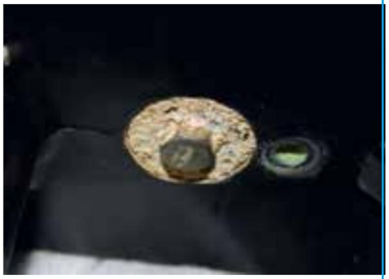
A wheelie bin filled with water is ideal for flushing the engine

2 Take the cover off and give everything a good squirt of WD40 now and then.

3 Before you put the engine away, turn off the fuel tap with the engine running and let it starve itself of fuel: this will empty the fuel lines and carburettor and prevent oily deposits in the carb.

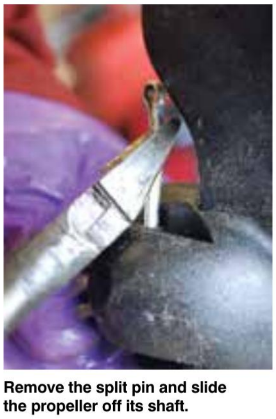
4 Check you have spare shearpins. Tape some to the inside of the engine cover so you'll know where to find them when you need them.

3. The anode

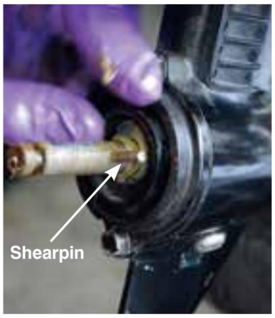


The anode is usually found on or under the cavitation plate. It's important that you replace an anode before it gets to the stage of the one in this photo. Make sure you replace it with the correct type for salt/fresh water.

4. Remove the propeller...



Remove the split pin and slide the propeller off its shaft.



Check the shearpin – remove, grease it and replace it. Remove any fishing line that has wound itself round the propshaft, grease the shaft and reattach the propeller.

...and finally

Now run the outboard in a tank of fresh water with the cover off to check it all works, before finally greasing anything that moves, especially the clamp screws and throttle.

Service a four-stroke outboard

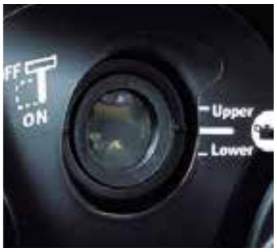
Ever since two-stroke outboards were banned from sale, new outboards will be four-stroke. Servicing is very similar – but there are a few key differences. Here's a quick guide.

Engine oil sump

Unlike two-strokes, where the oil is mixed with the fuel and is burned in the cylinder, four-strokes have a separate reservoir of oil which must be kept topped up. It can leak out if the engine is laid down incorrectly, so check the instructions printed on the side of your engine.

SERVICING: Replace sump oil every 100 hours by draining and refilling.

CHECK THE OIL: It should be between the two marks on the dipstick. Smaller outboards will have a sight hole instead (below). You can also check the gear oil level: remove the top screw and it should ooze gently out.



Oil filter

Larger outboards might have an oil filter. This removes contaminants from the oil to ensure the engine is lubricated correctly.

The filter should be replaced when the oil is changed. Lubricate the O-ring seal before screwing the filter back on using the correct tool, and tension it with a torque wrench so as not to overtighten.

SERVICING: Change every 200 hours.

Spark plugs

You're less likely to experience problems with a four-stroke outboard than a two-stroke as it doesn't burn oil and won't get as dirty.

Also check for any deposits on the electrode. A brown or grey colour is healthy. Don't check for a spark when there's likely to be explosive fuel lying around.

SERVICING: check every 100 hours, replace every 200 hours.

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Laying up CHECKLIST

Following a few simple procedures can help maintain your boat safely and securely over winter, says Ben Meakins

We're lucky in the UK. Unlike some places, your boat won't become entombed in ice if you don't haul her out as soon as the leaves begin to fall – and neither is she likely to be whisked away by a hurricane or typhoon. But even on our snug little island there are extremes of weather which can cause damage to your boat, and it's worth putting in some time to keep her safe and secure over the winter.

While the boat's in the water

☐ Leaks, as well as other problems you may have found as the year went on, can be impossible to trace when the boat's ashore. While you're in the water, take a photo, make a sketch or mark the affected area with a pen so you can identify and fix the problem.

☐ Take as much as you can off the boat. Empty lockers, bilges and cupboards, rinse them out and leave the locker lids off. It's easier to empty her when you don't have to shimmy down a ladder.

☐ Take your sails home or to a place where they can be washed and dried. Think about any sail repairs while the sailmakers are quiet – don't leave it until the last minute next spring.

☐ Take your liferaft for servicing as soon as possible. The service centres will thank you, and you'll get it back in good time for the new year.

☐ If the mast is staying up, check the rig. It's safer to send someone up aloft when the boat's in the water – and if you find anything amiss, the yard can take the mast down while it's easy to do so.

☐ While you're up there, remove masthead instruments and lights, aerials and wind indicators. They'll last longer and you can check for damage.

☐ If taking the mast down, unreeve any halyards, wires and strops to make the yard's job easier. Oil the bottlescrews and slacken them off a turn or two to make the boatyard's job quicker.

☐ Empty water tanks. If you have flexible tanks you can remove them and give them a scrub in the bath with a bottle brush – or if fixed, try filling them with a Milton solution before draining.

☐ Drain down any water heaters or calorifiers.

☐ Empty the holding tank. Imagine if a tank left full from last season was to freeze and burst… it doesn't bear thinking about! Pump it out at a pumping station or head out to sea.

☐ Top up your fuel tank to leave no room for condensation and the growth of the dreaded diesel bug. Consider using an additive.

☐ Take the cushions and any soft furnishings home, if possible – they'll stay drier, keep the boat drier and stop mildew growing. If you can't take them home, prop them up so that air can circulate underneath.

☐ After your final sail of the season, remove the speed transducer impeller – it risks damage from the crane strops.

☐ Remove anything that's easily removable and take it home to keep it safe – this is particularly important for items like outboard engines and chart plotters.

Before the big freeze

The boat is out of the water, but the worst of the British winter doesn't normally close in for a few more weeks – so what should you do to prepare for it?

☐ Freeze-proof the toilet: Pump through some diluted antifreeze to fill the pipes before you shut the seacocks for the winter.

☐ Wash, bail and dry the bilges and cockpit lockers with fresh water. If salty, they'll attract moisture from the air and never dry properly.

☐ Make sure the scuppers are clear, to stop water pooling and freezing on the deck. Make sure cockpit drains are also clear: this will be a regular task in the winter as they tend to clog up with leaves.

☐ Take the batteries home if you can, so they don't get damaged by the cold. If not, try to keep them trickle-charged: a small solar panel is ideal for this.

☐ Take 'perishable' items such as danbuoys and lifebuoys home, or keep them in a locker to stop them degrading.

☐ Flush your seacocks through to remove the salt, and grease them. It's better to do it now than when they've seized up later in the winter. If you have traditional Blakes-style seacocks, remove the barrels to stop them seizing up.

☐ Make sure the boat is well ventilated down below, or has a dehumidifier and/or a heater to keep the chill off.

Winterising the engine

It's important to winterise the engine to prevent damage from freezing. You can do most of this afloat, as there's nothing much to it.

☐ Change the oil. Fresh, uncontaminated oil will help prevent corrosion and protect the engine as it sits idle over winter.

☐ When the boat's ashore, you can flush the engine's raw water cooling system through – salty water could slowly corrode it from the inside out over winter. Close the inlet seacock, and allow fresh water to circulate through the engine while it runs – either using a hose, or by pouring it in using a jug. When you've done this, pour in some antifreeze solution, and stop the engine. If you're already ashore, check with the yard first to make sure the engine's vibrations won't shake the supports loose.

☐ If you have a closed-circuit cooling system, check the antifreeze level and top up as necessary.